SILICON CHIP

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...s first in
DIY Amplifiers!

- High Performance
- High Reliability
- High Power
- Easy to Build
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◆ 250W ◆ .01% THD ◆ 103dB S/N ◆ 90% EFFICIENT

Want to $ave $$?
REPLACE YOUR HOT WATER ANODE NOW!

It's Brilliant!
A 20W LED FLOODLIGHT TO BUILD

Jaycar Electronics

Better, More Technical

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12" Subwoofer

Buy 2 for $250 SAVE $48

High performance subwoofer. Finished in durable heavy vinyl, the cabinet houses a 12" 4 ohm subwoofer rated at 300WRMS. Perfect for music systems in bars, clubs, and parties etc. DJs will love it.

- Size: 480(W) x 580(H) x 440(D)mm

CS-2518

$149.00

HURRY! Limited Stock. Not available online.

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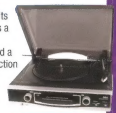
Listen to vinyl collections directly from the unit and its built-in speakers. Features a 3.5mm headphone jack, adjustable bass control and a line level output for connection to an external amplifier.

- Mains powered
- 33/45/78 RPM
- Stereo amplifier
- Size: 350(L) x 310(D) x 130(H)mm

GE-4136 *was $79.00*

$59.00 SAVE $20



BIRTHDAY BONUS

Ask for your **FREE** *Jaycar Cooler Bag when you spend $50 or more from our Birthday flyer*

6-Way Speaker Selector

Allows you to connect up to 6 pairs of speakers to your amplifier, and select any number of those pairs to play your music simultaneously.

- Solid metal construction
- Compatible with amplifiers up to 150 watts per channel
- Built-in protection circuit
- Size: 285(W) x 180(D) x 55(H)mm

AC-1683 *was $149.00*

$99.00 SAVE $50

Green DMX Laser Show

Produces over 100 green patterns with sound activation or DMX master/slave control.

- Mains powered
- Size: 205(L) x 80(W) x 145(H)mm

SL-3436 *was $169.00*

$149.00 SAVE $20

Dual Channel UHF Wireless Microphone

A two-channel system supporting two separate microphones. Each channel has a separately balanced XLR output. Includes two microphones and batteries, receiver unit and plugpack.

- Wireless range: 60m
- Receiver size: 210(L) x 170(D) x 42(H)mm

AM-4078 *was $149.00*

$129.00 SAVE $20

Also available:

Spare wireless Mic Ch A AM-4061 $49.95

Spare wireless Mic Ch B AM-4063 $49.95

2 Channel DMX UV Spotlight

Lightweight, compact and cool-running blacklight PAR 64 spotlight with 3 operating modes: sound-active, automatic and DMX control. Ideal for live performance stages, installations in night clubs or UV parties.

- 177 UV LEDs
- 240VAC mains powered
- Size: 240(W) x 200(H) x 310(D)mm

SL-3466

$119.00

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Excellent speakers for replacing old ones or for new speaker projects. Each speaker features a strong steel frame basket, high power magnet and voice coil, and concave treated paper cone matched with rubber surround to provide a smooth overall response. See website for specifications.

- Nominal impedance: 8 ohms

FROM $14.95 SAVE $10

4" 27WRMS Shielded Paper Cone Woofer/Midrange
CW-2190 ***was $24.95 now $14.95 save $10.00***

CW-2190

5" 50WRMS Shielded Paper Cone Woofer/Midrange
CW-2192 ***was $29.95 now $19.95 save $10.00***

CW-2194

6.5" 60WRMS Paper Cone Woofer/Midrange
CW-2194 ***was $34.95 now $24.95 save $10.00***

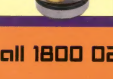
CW-2196

8" 90WRMS Paper Cone Woofer
CW-2196 ***was $39.95 now $29.95 save $10.00***

CW-2198

10" 225WRMS Paper Cone Woofer
CW-2198 ***was $59.95 now $49.95 save $10.00***

12" 225WRMS Stacked Magnet Paper Cone Woofer
CW-2199 ***was $74.95 now $59.95 save $15.00***



USB Rechargeable Mini FM Radio

Compact, portable mini FM radio with built-in MP3 player. USB cable included.

- Supports MicroSD card (not included)
- Built-in rechargeable Li-ion battery
- Size: 91(W) x 54(H) x 20(D)mm

AR-1738

$19.95

Lighting Stand

This strong and sturdy lighting stand will extend from 1530mm to 3650mm and is designed to carry up to 20kgs on the square section cross tree. The stand has 4 bolts for attaching up to 8 Pin Spots or other attachments.

- Collapsible legs (extends up to 750mm)
- Finished in matte black

CL-2800

$89.95

ATTENTION KIT BUILDERS

Can't find the kit you are looking for? Try the Jaycar Kit Back Catalogue

Our central warehouse keeps a quantity of older and slow-moving kits that can no longer be held in stores. A list of kits can be found on our website. Just search for "kit back catalogue".

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NEWSPAPER BREAKING NEWS!

3 DAY SALE

BG-200 Workshop Bench Grinder

- 200mm wheels (36 grit / 60 grit)
- 550W 240V induction motor
- Includes light, wheel dresser, cast aluminium tool rests & water tray

$115 (G159)

RAV2.75/36 Air Compressor

- 36 litre tank
- 2.75hp motor
- 205 L/min free air delivery
- V-Twin pump

$330 (C327)

5 Piece Air Accessory Kit

- Spray gun gravity type
- Degreasing gun with pot - long nozzle
- Tyre inflator with gauge
- Dusting gun with self coil hose

$33 (S445)

Metric & Imperial Drill Gauge

- Metric / Imperial
- Stainless steel
- 1-13mm
- 1/16 - 1/2"

$14 (M988)

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- Acme screw thread

No. 4

- 100mm
- 120mm max. opening

$55 (V088)

No. 5

- 127mm
- 150mm max. opening

$87.90 (V089)

No. 6

- 152mm
- 195mm max. opening

$120.60 (V090)

Engineers File Set Second Cut

- 200mm file length
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- 5 piece set

$25 (F100)

Jobber Drill Set

- 170 Piece 1-10mm
- HSS precision ground flutes
- 0.5mm increments

$158 (D126)

Drilling Machines

- 20mm drill capacity
- 1hp 240V motor
- Micro switch on belt cover
- 16 spindle speeds
- 2MT spindle taper

SBD-25A Bench Drill

$308 (D144)

SPD-25A Pedestal Drill

$352 (D147)

Hex Key With Ball End Long Series

- Metric 1.5-10mm
- Flip open design
- Ball head design allows turning of hard to reach fasteners from up to a 30° angle
- Sizes: 1.5mm, 2mm, 2.5mm, 3mm, 4mm, 5mm, 6mm, 8mm & 10mm hex keys

$14 (H501)

HSS Tap & Die Set

- Range: M3 - M12
- 32 piece metric set

$99 (T013)

EDBD-13 Drill Sharpener

- 3-13mm capacity
- 118° drill angle
- Capable of split point sharpening
- Grinds two flute drills of unlimited length
- 80W 4200rpm 240V DC motor
- Tough plastic construction

$99 (D070)

Carbide Burr Sets

- Double cut industrial quality
- 1/4" shank
- 5 piece set

Short Series

- SD-3, SE-3, SA-3, SC-3, SF-5
- 1/4" x 1-1/2" shank

$66 (B900)

Long Series

- SD-3, SD-5, SG-5, SC-5, SF-5
- 1/4" x 6" shank

$77 (B905)

SP-900 2 x Backing Panels Square Hole Type

- Powder-coated finish for heavy-duty service
- Dimensions of each louvre: 900 x 456 x 20mm
- Square holes suits optional hooks & holders

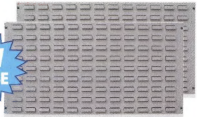
$49.50 (A412)

NEW RELEASE

LP-900 2 x Backing Panels Louvre Type

- Powder-coated finish for heavy-duty service
- Dimensions of each louvre: 900 x 456 x 20mm
- Louvre slots to suit optional buckets

$49.50 (A410)

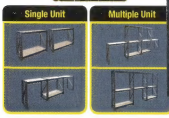


RTS-4T Flexi-Rack Wood Shelving

- 455kgs shelf load capacity
- Can be configured as a work bench
- Multiple configurations
- 4 adjustable shelves
- 1040 x 430 x 1830mm (L x W x H)

$154 (S013)

CONFIGURATIONS



Optional Hooks - suit SP-900	CODE	PRICE
Single Hook 75mm long	A440	$2.20
Double Hook 75mm long	A442	$2.20
Plier Holder - 3 Prong 150mm long	A444	$3.30
Spanner Holder - 135mm long	A446	$7.70
Screwdriver Holder - 390mm long	A448	$11.00

Optional Storage Trays - LP-900	CODE	PRICE
110 x 105 x 50mm	A430	$2.20
140 x 105 x 75mm	A432	$3.30
220 x 140 x 125mm	A434	$7.70
270 x 140 x 125mm	A436	$11.00

Specifications & Prices are subject to change without notification. All prices include GST and valid until 17-11-12

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THURSDAY 15th - SATURDAY 17th NOVEMBER 2012

FREE SAUSAGE SIZZLE

Digital Angle Rules
- Absolute & incremental
- Zero button
- 360° Range

180mm / 7" $27.50 (M970)

280mm / 11" $35 (M972)

480mm / 18" $42 (M974)

Fluroescent Work Lights
- Designed with magnifier lens (L282)
- Double lamp tubes (L282S)
- Long arm
- 240V

22 Watts $132 (L282)

36 Watts $149 (L282S)

Digital Scale With Display Unit
- On/off in any position
- Remembers the last setting
- Metric or imperial digits
- Mini USB connection to the display unit

620mm $73 (D665)

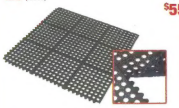
900mm $92 (D667)

NIC Portable Video Scope Camera
- 1 metre flexible cable with 12.5mm diameter camera head & LED lighting
- Includes: 2 metre extension cable, pick up hook, magnetic pick up tool, mirror tool & carry case

$159 (M697)

RFM-900 Rubber Mat
- 910 x 910mm (10mm thick)
- Clips together

$29 (M805)



Digital Bevel Box
- Digital readout display
- 3 embedded disc magnets on base
- 0.1 degree resolution
- 180° range
- Accurately sets saw blade angle

$55 (M977)

Digital Calipers
- Accuracy DIN862
- Large clear LCD screen
- Splash proof electronic unit
- Four way measurement

31-180 150mm/6" $83 (Q180)

31-181 200mm/8" $107 (Q181)

31-182 300mm/12" $158 (Q182)

6 Piece Pin Punch Set
- 6pc pin punches (tip diameter x shaft hex x length)
- Ø3 x 10 x 150mm
- Ø4 x 10 x 150mm
- Ø5 x 10 x 150mm
- Ø6 x 10 x 150mm
- Ø7 x 12 x 150mm
- Ø8 x 12 x 150mm

$15 (P365)

WCH-6D + WRC-5D Tool Chest & Roller Cabinet Package

WCH-6D
6 Drawer Tool Chest
600 x 260 x 340mm (L x W x H)

$77 (T690)

WRC-5D
5 Drawer Roller Cabinet
616 x 330 x 762mm (L x W x H)

$176 (T695)

PACKAGE PRICE ONLY $239 (K004)

SAVE $58 RRP

CS-55 Circular Plunge Cut Saw
- 55mm cut depth capacity at 90°
- 41mm cut depth capacity at 45°
- 5500rpm blade speed • 0-45° mitre cutting
- 1.2kW / 1.6hp 240V motor
- Includes: cs-55 circular plunge cut saw with ø160mm blade x 24 teeth, 1400 x 200mm aluminium guide rail, clamp & stop accessories pack & anti fall over saw clamp

$275 (W874)

NEW RELEASE

14 Piece Punch & Chisel Set
- 5 x flat cold chisels
- 4 x tapered punches
- 4 x pin punches
- 1 x center punch

$44 (P364)

ETT-1D Engine Tear Down Table
- 1220 x 710mm table top
- 136kg table capacity
- Key lockable drawer
- Includes fluid recovery pan

$242 (A385)

PROCRAFT 240 MIG Welder
- 30-240 Amps, 240V / 1 phase
- Gas / gasless MIG
- Spool size 5 & 15kg
- Includes: argon regulator, gas hose & MIG torch

$770 (W185)

AL-250G Bench Lathe
- 250 x 500mm turning capacity
- 26mm spindle bore • 12 spindle speeds
- 1hp, 240V motor • Forward/reverse spindle switch
- Enclosed quick action gearbox for thread cutting & auto feeding
- Adjustable taper roller spindle bearings

$1,529 (L149)

HM-36 Mill Drill
- 3MT spindle, 6 speeds
- Gear driven head
- Tilting head to ±90°
- 730 x 210mm work table
- 1.1kW / 1.5hp 240V motor
- Inludes: Drill chuck & arbor, 3MT-2MT drill sleeve, multi-point facing cutter & safety cutter guard
- Travels: (X) 475mm (Y) 195mm (Z) 450mm

$1,595 (M122)

TEC-1G Auto Darken Welding Helmet
- 9-13 adjustable shade
- Darkens in 1/16,000 sec
- Viewing area 98 x 44mm
- Protects from UV & IR radiation

$75 (W009)

NEW RELEASE

ST-250G Lathe Stand
$220 (L150)

MDS-H Mill Drill Stand
$220 (M135A)

HURRY SALE ENDS 17th NOVEMBER 4:00pm

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Publisher & Editor-in-Chief
Leo Simpson, B.Bus., FAICD

Production Manager
Greg Swain, B.Sc. (Hons.)

Technical Editor
John Clarke, B.E.(Elec.)

Technical Staff
Ross Tester
Jim Rowe, B.A., B.Sc
Nicholas Vinen

Photography
Ross Tester

Reader Services
Ann Morris

Advertising Enquiries
Glyn Smith
Phone (02) 9939 3295
Mobile 0431 792 293
glyn@siliconchip.com.au

Regular Contributors
Brendan Akhurst
Rodney Champness, VK3UG
Kevin Poulter
Stan Swan
Dave Thompson

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Editorial office:
Unit 1, 234 Harbord Rd,
Brookvale, NSW 2100.

Postal address: PO Box 139,
Collaroy Beach, NSW 2097.

Phone (02) 9939 3295.

Fax (02) 9939 2648.

E-mail: silicon@siliconchip.com.au

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Publisher's Letter

Replacing sacrificial anodes in hot-water systems is good for the environment

This month, we have a seemingly low-tech story about replacing the sacrificial anode in a mains-pressure off-peak hot-water storage tank. Why would we have such a story in SILICON CHIP? Well, why not? SILICON CHIP readers are concerned about energy efficiency and as a corollary of that, in getting the best performance from anything electrical or electronic. And hot-water systems certainly fit into those criteria.

There are millions of these tanks in homes and businesses throughout Australia and yet most owners and users of these tanks are blithely unaware that there is such a "thing" as a sacrificial anode in their tank and that it should be inspected and replaced on a regular basis. Of course, this does not only apply to mains powered hot-water systems. It also applies to gas fired systems, solar hot-water systems and even those that use a heat pump as the power source; anything with a steel storage tank and with mains water pressure is at risk of corrosion and eventual failure.

And yet I know that if you ask all your acquaintances about the state of the sacrificial anode in their hot-water systems you will get a blank stare from virtually all of them. Boat owners know about sacrificial anodes but virtually no-one else does, including the people who install them: plumbers.

Boat owners do have their sacrificial anodes replaced regularly, usually every year, but those same owners probably don't know about the one in their hot-water system.

What this means is that virtually all the millions of hot-water systems in use throughout Australia give far less than their potential life span. And since most mains-pressure hot-water systems typically last less than 10 years, precisely because their sacrificial anodes were not replaced when they should have been, that probably means that the annual cost in Australia runs into 100s of millions of dollars a year.

It get worse though, if you consider the cost of replacing solar or heat-pump systems. These generally cost far more to install than the lowly and these days much-despised off-peak electric hot-water systems yet as far as I know, owners of these systems are seldom specifically told about the need to inspect and replace sacrificial anodes.

Solar hot-water systems are even more at risk because they typically have a roof-mounted horizontal tank, unless you are fortunate enough to have purchased a stainless steel tank which does not need a sacrificial anode! Roof-mounted tanks may not be out of sight but their corrosion risk is certainly out of mind.

So while many people may worry about the cost of electricity and more specifically, the cost of hot water, they are completely unaware of the possible liability for the large one-off cost of replacing the entire hot-water system. Think about the cost of the tank and its installation.

Personally, I want to keep my off-peak hot-water storage system going for as long as possible because there is no guarantee I will be able to replace it with a similar unit when it eventually fails. Ultimately, I will probably replace it with a solar system but I would prefer to postpone that as far into the future as possible.

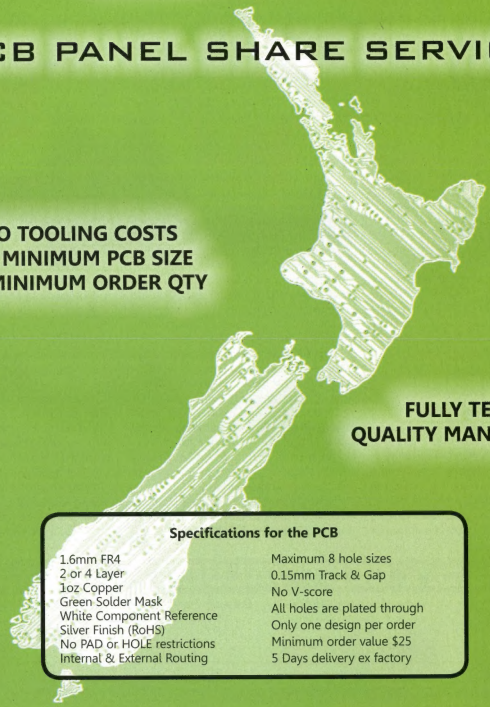
I also like to think that I am being "environmentally friendly" with such an approach. Sure, I am potentially saving money but then I am also saving the resources which would otherwise be required to replace the tank.

So here is our strong suggestion. Get your hot-water system's sacrificial anode inspected.

Leo Simpson

PCB ZONE

PCB PANEL SHARE SERVICE



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Nissan Leaf is just too expensive

With reference to the recent mail on the subject, would you be more likely to buy a Nissan Leaf if it were $35,000 or a Mitsubishi iMIEV for $30,000?

These are the prices in the USA before their Government subsidy. Surely at these prices many more Australians would take up an electric car. Note that the price difference is not Australian tax; they are not classed as luxury cars.

Last time I looked at a map, Australia is closer to Japan than to the USA so freight is not the issue.

The only reason I can think of for the much higher prices is that they charge that much because they can. I suggest that readers ask their local Nissan and Mitsubishi dealers to justify their pricing policy. Maybe exposing the price difference and publicly shaming them is the only way to get electric car prices to be more realistic.

Arthur Davies,
Canberra, ACT.

Destructive echoes in digital TV reception

I would like to comment about an aspect of digital TV (DVB-T) reception.

I install TV antennas in Perth and specialise in difficult TV reception problems. According to various papers on DVB-T (Digital Video Broadcasting – Terrestrial), the signal structure has an in-built protection mechanism to render it immune to multipath propagation (ie, echoes) within a period known as the "guard interval".

As I understand things, VHF transmissions in Perth currently use a guard interval of 1/16 and UHF 1/8. These equate to time intervals of about 64µs and 128µs respectively. Echoes that occur in less than 64µs/128µs should not affect reception.

Radio waves travel at a nominal 300 metres per microsecond, so echoes that travel less than 19.2km to 38.4km respectively should have no effect on reception. In general this protection mechanism seems to do a good job in many locations. However there are locations where it fails and results in serious pixellation or no reception for one or more channels. This can occur in areas of both weak and strong signal strength and for both VHF and UHF.

The echoes can come from anywhere in a 360° azimuth. The echoes are signal reflections mainly from stationary, man-made metal structures which are many and varied, eg, metal masts or towers, metal-clad buildings and reinforced concrete structures. Echoes from hilly terrain and trees have been in the minority around Perth, in my experience.

Echoes can cause frequency selective attenuation and corruption of signal. They can cause large loss of signal over a large portion of the channel bandwidth. The loss can vary from 10dB to more than 20dB for 20-30% or more of the channel bandwidth. The error rate can be rendered beyond the "cliff edge" and the signal not be decoded.

Not all echoes cause problems but some definitely do. Some cause more corruption than others and I will refer to them as destructive echoes. Using timing/distance measurements from my meter, I have determined that in many cases destructive echoes have entered via the back of the antenna and in some cases via the front. The destructive echo delays have varied anywhere from less than 2µs to about 45µs. This relates to distances that vary from less than 600m to about 13.5km. These delays are well inside the guard interval.

When destructive echoes have entered from the back half of the antenna it is because it has a poor front-to-rear ratio. In these cases, one successful method to reduce the signal corruption has been to replace the antenna with another that has a better front-to-rear ratio. This generally results in increased signal level, less loss across a large portion of the channel

Australia's BEST VALUE Test Equipment

Agilent DMMs
from **$98.95***

Wide-Screen DSOs
with USB and Digital Filter,
from **$329.00***

Bench Power Supplies
30V, 5A
from **$87.95***

4-in-1 Test Station
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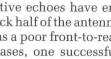

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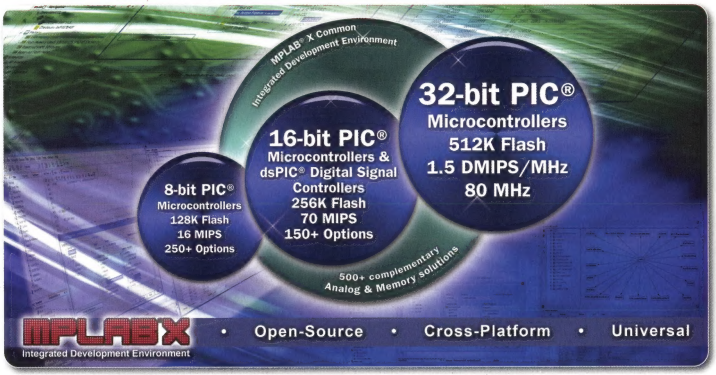

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Mailbag: continued

A tricky fault in the DAB+ tuner

I read with great interest the recent Serviceman account of the DAB+ Tuner fault. I built the same tuner from the Jaycar kit and experienced exactly the same fault which I had thought at the time was probably temperature related. I tried checking and resoldering most of the joints on the PCB to no avail.

While doing that I noticed that touching the board with my finger in the vicinity of IC2 eliminated the distortion. I then found that touching a metal probe to the fourth pin from the right in the first row of the Venice 7 mounting pins (the row nearest IC2) also eliminated the distortion. I figured that there must be some capacitive effect occurring so I then soldered a 33nF capacitor between that pin and earth to "permanently" fix the problem.

I realise this is probably pretty unorthodox and not really a fix but it worked. After reading the Serviceman's account, I will now try and duplicate his fix to effect a permanent cure. Incidentally, I am in an area that does not have any digital radio services so I have only been using the tuner on FM and in spite of some early frustration over the distortion problem I am quite pleased with its performance.

David Hebblethwaite,
Maleny, Qld.

bandwidth and improved error rate to bring it above the "cliff edge".

The antennas that have given best results are plane reflector types that give typical front-to-back ratios of a nominal 20dB or more and front-to-rear ratios of 14dB or more across the whole of the relevant band. The plane reflector is made of mesh to reduce wind loading. The feeds have comprised simple dipole arrays and in one VHF design the feed and directors of a Yagi.

There are other aspects and techniques that can be associated with the improvement but will not be discussed here. From my experience, destructive echoes are a major cause of signal failure in locations of difficult reception. In many cases, this can be overcome by using a suitable antenna for the particular situation.

The main purpose of this letter is to highlight that the "guard interval" does not always protect the signal from echoes and that the radiation characteristics of the antenna can play a big part in overcoming destructive echoes. These two points do not seem to get mentioned in articles or papers on the reception of DVB-T signals.

When installing antennas I use a UNAOHM Proteus T40 DVB-T field strength and analog meter.

Mike Hale,
Maylands, WA.

Error in Bass Sweeper circuit

The Bass Sweeper in the Circuit Notebook pages of the October 2012 issue reached me right on time as I'm designing and about to build a new subwoofer enclosure.

Unfortunately, there is a drafting error in the schematic, as I've verified by a spreadsheet simulation of IC4 and IC5. The input resistors to IC5 from IC4 outputs O0b to O3b should be the same in reverse order as those from O0a to O3a. In the drawing, the lowest three have been moved up one place and O3b left unconnected to IC5.

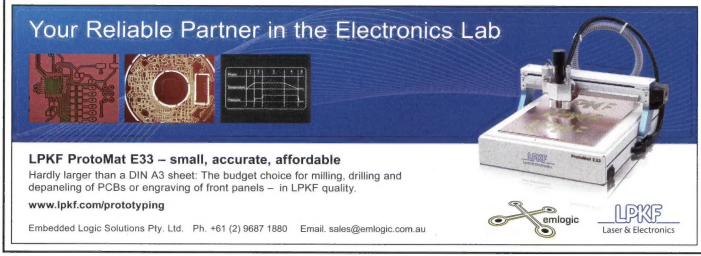
Without running or converting the spreadsheet, you can verify this by considering the shift register when it contains 00001111. With the above change the voltage at the summing input of IC5 will be half the supply (assuming the outputs swing from 0V to 12V) and the output terminal will be passing through zero. Without the change, the sine approximation is not 16 steps long and does not include a step at zero output.

Brian Stone,
Canberra, ACT.

Australia's ionosphere research program

I was interested to read the article on the US HAARP project in the October edition and thought your readers may like to know that sites like HAARP have run in Australia in the past. It brought back memories of my student days at the University of New England (UNE) in northern NSW.

UNE is located in Armidale, a sheep-grazing area in NSW, about 500km north of Sydney. For a number of years from the early 1950s to the mid 1970s, the UNE Physics department, in co-



Congratulations on LED Musicolour

I have just picked up my copy of SILICON CHIP for October 2012 and I am writing with regard to the LED Musicolour project in that issue. As I started to read the article I realised just what was happening inside that little block of beach sand (the DSC chip) and it was then that I comprehended that this is no small piece of software. I don't know how another feature could possibly be included in the program as it is chock-full. As a PIC chip programmer myself, I know that this is one mighty fancy bit of code.

I congratulate SILICON CHIP for producing the project and my hat certainly comes off to Nicholas Vinen for his work on it. It takes a very clever person to be able to write a program of this complexity. Well done Nicholas.

Jeff Monegal,
Jimboomba, Qld.

operation with Sydney University, operated an extensive ionosphere research program.

In the early 1960s, as part of this research, the US Department of Defence funded an expansion of the transmitter facilities at the UNE. This allowed the construction of what was possibly the first large-scale ionosphere probing transmitter in the world.

The main difference between the UNE facility and the current HAARP project is that the university transmitter beam was not steerable and ran at a fixed frequency of 1.515MHz. We had a single large transmitter and antenna rather than a number of smaller units.

The transmitters, antenna and a small number of equipment buildings were located in a rural area about 12km from the university. The main transmitter was rated at 500kW continuous with a pulse power of 2MW. The transmitter was powered by its own 66kV feed from the NSW electrical grid.

While the main transmitter was simple in design, everything about it was large. It looked like a normal transmitter built from giant components. Most of it was constructed in a metal-lined room. The coils were adjusted using mechanical linkages from outside the room and the transmitter valves stood close to a metre tall.

The antenna was equally large, covering an area of 550 metres by 550 metres. It consisted of a 40-dipole array which transmitted a highly directive circularly-polarised wave straight up. Each dipole was in the form of a cage of four wires, 100 metres long, and suspended on wooden poles 30 metres above the ground. To ensure that very little of the radiated energy was lost in the ground, over 30 kilometres of copper wire was buried below the array to form a ground reflecting mesh.

One difficulty with using the transmitter was that it ran in the middle of the AM broadcast band. As this single transmitter was probably equal in power to the total of all commercial broadcast band transmitters in Australia, there were naturally a few restrictions on transmissions. The main transmitter could only be run from midnight to dawn but as a trade-off, we had exclusive use of a narrow range of frequencies during the early dawn hours.

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Mailbag: continued

AWA centenary in 2013

The electronics company Amalgamated Wireless Australasia (AWA) was established in July 1913. To celebrate the centenary of this important company, the AWA Veterans Association will be organising an event at the Burwood RSL Club, 96 Shaftesbury Road, Burwood (NSW) on Sunday 28 July 1913, commencing at 9.30am. This event will take the form of an exhibition of equipment manufactured by AWA and talks by guest speakers.

Time will be given for reminiscing about earlier days in the electronics industry. Not only ex-employees of AWA will be welcome but anybody else interested in this company or the industry in which it operated.

The cost of $40 will include a fully-catered meal and morning and afternoon teas between sessions. If you think you might be interested in attending, email **awaveterans@gmail.com** and you will be placed on an email list to be kept in touch. Alternatively, you could telephone the undersigned on (02) 9553 8916.

Ross Stell,
AWA Veterans Association,
Kogarah, NSW

You may wonder why megawatt transmitters are needed to research the ionosphere. As Dr Maddison explained in his article, much of the research is to do with understanding the electron density in the ionosphere and the interaction between radio waves and the ionosphere. When a radio wave travels through the ionosphere, it sets the electrons into oscillation until these oscillations are dampened by collisions with gas molecules.

The UNE transmitter was used to send megawatt pulses at just over 1.5MHz into the D region and lower E region of the ionosphere. Each pulse accelerated electrons which then cooled as they collided with the tenuous gases in the ionosphere. By sending very short probing pulses from smaller transmitters through the heated area and studying the echoes, it was possible to determine how slowly the pulse decayed at various heights and thus the electron density and chemistry at different heights.

For example, it was possible to analyse the effect of sunrise on the D-region and the resulting major changes on radio propagation. It was also possible to study ionospheric cross-modulation between radio signals, where reception of one radio signal includes an influence from another signal.

The main transmitter ran at 1.515MHz as this is the frequency of electron oscillations in the Earth's magnetic field over Armidale. It is the so-called electron "gyrofrequency".

The smaller probing transmitters used to investigate the decay of the main transmitter pulses were rated at 10-20kW and operated at about 2.2MHz. These were not originally crystal-locked and on more than one occasion there were friendly calls from the PMG's Department about an unknown transmitter running into the marine distress frequency and setting off alarms on ships along Eastern Australia.

One modern illustration of the importance of understanding ionosphere electron density is the GPS system we use every day. Understanding ionosphere electron density was critical to the initial development of GPS systems in the 1970s, as the electron density changes the speed of the satellite radio signals. The main limitation on GPS accuracy remains the continuous changes to electron density in the ionosphere.

Locating HAARP in Alaska is very important scientifically, as in this region one can see the interaction between energetic particles ejected from the Sun (the "solar wind") and the Earth's magnetic field. We can see this energy in the Aurora Borealis. Part of the energy also goes into large electrical currents flowing in the upper atmosphere at an altitude of about 100km. These currents are strong enough to disrupt ground electrical networks

Vale Neville Thiele, 1st October, 2012.

It saddens me to tell you of the death of my close friend and mentor, Neville Thiele OAM, who passed away in Sydney on 1st October, 2012.

Neville was a thorough gentleman and a legend in his own lifetime through his meticulous engineering work on filters and loudspeakers. In his earlier years, he worked at EMI in Sydney and even became involved in rocketry at Woomera, as well as designing the first EMI TV receiver for Australia.

His legendary paper "Loudspeakers In Vented Boxes" was first published in the Journal of the IREE Australia in 1961 and was later reprinted in the Journal of the AES (USA), in 1973. Later on, in collaboration with Dr Richard Small, then working at Sydney University, the now famous "Thiele/Small parameters" for loudspeaker measurement came into being.

After leaving EMI, he joined the ABC and later became Director – Engineering Development and New Systems Applications. He was responsible for the ABC's engineering research and development until his retirement at the end of 1985. In 1994, he became Honorary Associate at the University of Sydney and taught loudspeaker design in its Graduate Audio Program.

I first met Neville around 1968-69, soon after starting my business, and found an instant friend with our many common interests in baroque to modern music, electronics, loudspeakers and sound reproduction, as well as bushwalking and the Goons! He introduced me to his 1961 IREE paper and virtually took me under his wing, explaining the measurement methods and then would mathematically analyse my measurements. All this was done over the phone at night and back then, he did all the calculations manually at first, and later on an HP 41C calculator. I was naturally highly impressed by his meticulous work and enthusiasm, combined with a great sense of humour.

I recall my absolute amazement when on one occasion, after thoroughly measuring a loudspeaker for his analysis, he got back to me a few days later and said, "I think you have a leak in the box." And he wasn't referring to the brand of speaker either! As all our communication was by telephone and he had never even seen the box or drive unit, I soon realised that he was bound to become famous through this analytical work. One loudspeaker resulting from this early work was our Prague 2 system, favourably reviewed in *Electronics Australia* magazine in the early 1970s.

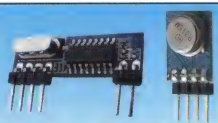
Left-to-right: Neville Thiele, Ron Cooper and Dick Small at a get-together in Collaroy, NSW in April 2010.

When developing our wideband AM tuner, his suggestions in several design areas were often quite simple, yet when done correctly under his tutelage, led to amazing results as evidenced by the reviews in *Electronics Australia* and its subsequent acceptance by many.

Around January 2002, my wife Jan and I hiked with Neville from Charlotte Pass to Mt Kosciuszko and at the age of 82 it was a goal that he wanted to achieve. With a few rest stops, he reached his goal and it was exciting to see his joy when standing on the viewing platform in a howling gale. I told him, "You are now the highest person in Australia!"

Neville was a fantastic friend and true engineer, able to achieve amazing results without complications. He will be greatly missed by many, in Australia and worldwide.

Ron Cooper, Audiosound Laboratories, Curl Curl, NSW.



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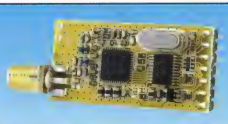

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Mailbag: continued

near the poles. Currents can exceed one million amps, spread across a belt 100km wide. The upper atmosphere at the poles is a fascinating area.

In conclusion, while HAARP is impressive, it is a continuation of research that dates back to the early days of radio and is not far removed from work that was being done in Australia 40-50 years ago.

John Cameron,
Roseville, NSW.

Employing solar power as a mains backup

I have just read the "Off-Grid Solar Queries" letter in the Ask Silicon Chip pages from the September 2012 issue and would like add my own thoughts on what the original correspondent is getting at.

When the first MPPT charger design was published, I looked at it and thought it's a pity that it doesn't put out 230VAC. A few thoughts later and I had in mind a device that would take the DC from a few panels and generate 230VAC to supply a small number of mains-powered items. It would also take 230VAC from the mains and substitute that when there was insufficient solar power. It was only when you published the Induction Motor Speed Controller that I figured the (not unjustified at all) reluctance of Silicon Chip to publish high-power potentially dangerous circuits had somewhat diminished and that it might be worth putting this suggestion forward.

In solar power installations, there seem to be two options: grid-connected and remote area with batteries. There is nothing in between for somebody who can't afford or doesn't have suitable roof space to put up even a minimum-scale grid-connected system. Here's where SolarAssist (as the folder of notes I have scrawled on the idea so far is labelled) comes in.

I would be aiming at somewhere between 500W and 1kW in capacity, which seems to be two to four panels. It would be ideal if all available power from the solar panels were used before supplementing the output power from the mains though I haven't thought of a way to do that yet. At worst, it's a cut over from one to the other. Ideally, when running from 100% mains, there should be no insertion losses. If that leads to relays at the output, then the inverter needs to be mains synchronous too.

Rather than a string of power boards to distribute my synthetic mains, my electrician (who does a lot of solar stuff and is quite interested in how this all turns out) ran me an extra circuit around my office with its own RCD and earth tie in and a 230VAC male connector like a caravan. He also put up my two 250W 24V panels. I think there are potential hazards of using synthetic mains if it's not properly earthed and the users are not properly protected with RCDs so I am glad to have that done properly.

I have been considering how to hybridise the MPPT charger, the Induction Motor Controller and some mains input, with different software to experiment with this,

but I plan a quicker and easier proof of concept with much less work first. I am going to co-opt a computer UPS, probably a disused APC unit.

I intend to connect the MPPT charger to the batteries in the UPS (they are probably worn out anyway but batteries are not part of the idea at all so that doesn't matter). Then I intend to fool the UPS into working with opposite logic to what it usually does. A solar powered relay on the mains input to the UPS should do it.

When the sun is shining, the UPS loses mains and thinks it should run on its batteries, which is really the power from the panels coming through the MPPT charger. When the sun goes in, or at night, the relay drops out and connects the mains back up to the UPS and power is maintained.

In my case, I am only interested in powering the things that are always on in my home office such as laptops, PCs, modems, switches, printers etc. So 500W should be plenty. I have measured my usage at about 260W.

In economic terms, it is all probably a folly really because the power generated in this way only offsets grid power at the grid price, not at the solar feed-in tariff price a grid-connected system would provide. This probably doubles the payback period.

I am not an accountant but I am going to feel much better that these devices are running off sunshine whenever they can.

As projects go, it exceeds my expertise and while that wouldn't stop me, it means that I am not familiar enough with the kinds of pitfalls that this design could have and without trial and error I don't intuitively know the "best" architecture for the solution. It's very pleasing that somebody more skilful than me is onto it.

Alan Williams,
Old Noarlunga, SA. SC

Speed controller for pool pumps

In the "Ask Silicon Chip" pages of the September 2012 issue, R.F. from McCare, in Victoria, was asking about the economic feasibility of the Induction Motor Speed Controller for pool pumps.

Our pool pump is rated at 1HP and measured 922W when running without the speed controller with a supply voltage of 241VAC. Using a tacho, I measured the motor speed to be about 2800 RPM.

Using the Silicon Chip Induction Motor Speed Controller, I set the speed close to 2000 RPM (a little over 70% of full speed) and this resulted in a wattmeter reading 410W.

So 922W x six hours daily = 5.532kWh x 34.419c/kWh = $1.904 per day x 95 days (average billing cycle) = $180.90

410W x six hours daily = 2.46kWh x 34.419c/kWh = $0.8467 per day x 95 days = $80.43; a saving of $100 per quarter.

At $229 for the kit, you will easily get your money back inside a year if running the pump for six hours per day.

I don't have any way to measure the flow rate of the pump. The motor runs more quietly, barely gets warm and the filtration seems to be unaffected. Hope this information helps.

Geoff Coppa,
Toormina, NSW.

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WANT TO $AVE REAL DOLLAR$ IN THE FUTURE?

Sacrifice yo
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Do you have a mains-pressure storage hot water system? Is it five years old or older? Then you probably should make arrangements to have its sacrificial anode replaced, to ensure at least another five or six years life before it fails. Replacing the anode is straightforward, cheap and will save you lots of money.

In these days of "carbon pollution panic" and dire predictions of climate change havoc, electric off-peak hot-water systems are supposedly regarded as wasteful and to be avoided.

So much so that they are prohibited in new homes and there is a possibility that they will be banned from sale in the future for replacement of existing systems.

Either way, it is in your interest to keep your existing off-peak storage hot-water system going as long as possible. Replacing it will be costly and if replaced with a gas instantaneous or storage system, it is likely to be more expensive to run.

There are two ways to ensure long life in any mains-pressure storage hot-water system. First, keep the thermostat to as low a setting as is practical.

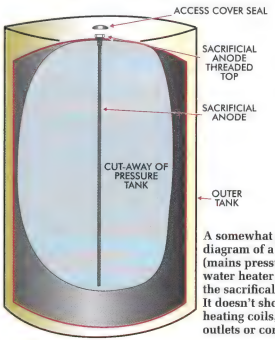
Normally, it should be set to no more than 60°C. Any higher setting causes increased thermal cycling stress in the tank itself, not to mention the increased risk of scalding to infants and elderly people.

Second, make sure that the sacrificial anode is working, ie, being sacrificed to protect the tank. That's if it is indeed still there – there's a distinct possibility that it will have been worn away, either mostly or even completely.

What's a sacrificial anode?

By way of explanation, all storage hot-water systems, be they electric, gas-fired, solar or heat pump, use a steel tank which is lined with a vitreous coating. As time goes on, that vitreous coating is subjected to a lot of stresses and inevitably, very fine cracks develop and allow the hot water under pressure to come into contact with the tank and then corrosion starts.

Or at least it would, if the tank was not fitted with a sacrificial anode. As its name suggest, it is "sacrificed" and it corrodes before the tank does. The anode is usually made of magnesium, a metal which is more "active"



A somewhat stylised diagram of a storage (mains pressure) hot water heater showing the sacrifical anode. It doesn't show the heating coils, inlets/ outlets or control gear.

By LEO SIMPSON

ur node!

This sacrificial anode is about five years old. Even though it's not too far gone, for the purpose of this article we decided to have it replaced. Note that there is insufficient headroom above the tank to enable it to be fully removed. You would need a segmented anode for this job (the inset photo shows a non-segmented type – see overleaf).

(with a more negative electrochemical potential) than the steel of the tank.

All of which is good but if you leave the sacrificial anode for too long, it will be sacrificed too much and then the tank's life is quite limited. Unfortunately, by the time you notice that the tank is leaking, it is too late to do anything about it and it must be replaced. That's expensive.

If you live in Sydney or other Australian city or town with a "soft" water supply you can normally expect to get about ten years or less from a hot-water tank. Or at least, that's what most people get because they don't know about the sacrificial anode and its function.

Incidentally, sacrificial anodes are also found on ships, larger boats and even outboard motors, for exactly the same reason – they prevent the hull or motor being eaten away by electrolysis. But we digress.

In most hot water systems the sacrificial anode is in the form of a long (magnesium) rod which hangs down inside the tank and is suspended from the top plate. It is quite easy to inspect and replace and we will go through the steps in a moment. You can do it yourself with the only tool required being a socket spanner or if you are not confident about meddling with your tank, a plumber can do it.

At this stage we should state that most plumbers seem quite ignorant of the facts that first, hot-water tanks do have sacrificial anodes and second, that they should be inspected or replaced at specified intervals. And some plumbers take the attitude that if the tank is more than a few years old, it should not be disturbed in any way.

That's silly. First, it's an easy service for a plumber and second, they only have to read the manufacturers' info to find out the details.

To illustrate, some 13 years ago a company specialising in servicing hot water systems contacted me and suggested that the sacrificial anode in our hot-water tank should be inspected and replaced. By that time, the tank was about seven years old. Inspection revealed that the anode was very heavily corroded but still intact and it was strongly recommended that it should be immediately replaced. I agreed and it was only about ten minutes work.

Fast forward some seven or eight years to late 2007 and one day I noticed that the outside of the tank seemed quite warm. In fact the top of

An example of a sacrificial anode that really has worn right away. The central iron core is now clearly visible which means that the anode is now playing no part in protecting the iron tank. It would be very suprising if this hot water system was not badly leaking.

Here's a "segmented" sacrificial anode, designed to be inserted into the tank where there is insufficient headroom to fit the "straight" variety. Each of these segments can bend with respect to one another and re-straightened as it is inserted into the tank. It's important to note that the anode must not touch the walls of the tank inside or it may actually contribute to rapid corrosion, not protect from it.

the tank was more than warm; it was hot. I duly removed the plastic inspection disc at the top of the tank, only to discover that the insulation was quite wet.

Hmm. I had left it too long to replace the anode.

About a month or so later, the tank was clearly leaking and subsequently I had it replaced with a virtually identical 315-litre model.

As a matter of interest, the sacrificial anode had completely gone and its mating thread in the tank had heavily corroded, leading to the leak. Still, the good thing was that I had achieved about 15 years from the tank; quite a bit longer than the average of 10 years which is typical of a mains pressure off-peak hot-water system in Sydney.

But how much more life would I have obtained if the anode had been replaced in reasonable time?

Fast forward again, to July 2012, and we were about to have some major home renovations done and as part of the deal, the hot water tank was to be moved from inside the laundry to a store-room nearby. By this time the tank was only five years old but I decided to obtain a new sacrificial anode and have it replaced at the same time.

Now here is the tricky bit. Many storage hot-water systems are in rooms where there is limited headroom above the tank. A 315-litre tank is about 1.6 metres high (depending on whether it has been mounted on a plastic or concrete pad) while the anode itself is 1.4 metres or thereabouts.

You need more than one metre of head-room above the tank if you are to remove it without bending it. And even if you do manage to bend the old anode sufficiently to remove it, how can you manage to get the new one in?

Fortunately there is a solution: flexible segmented anodes. The segments are about 300mm long and so the anode can be bent (carefully!) to insert it into tanks with limited headroom.

In my case the limited headroom did not matter because the anode replacement could be done when the tank was being moved by the plumber. But for the purpose of this article, I purchased a segmented anode.

Where to buy a sacrificial anode

You need to contact a plumbing supplier with the make and model of your hot-water tank, and if possible, the recommended anode type, which should be in owner's handbook. If not, contact the tank manufacturer.

You're most unlikely to find a sacrificial anode at your local hardware store, even if it does have a good range of plumbing fittings – it is most unlikely to stock sacrificial anodes.

In fact, you may well find that the plumbing specialist store will have to order one in for you. However, this is not foolproof: they need to know what you want!

After talking about sacrificial anodes, another of our staff members was prompted to change his. So he went into a local plumber's "wholesaler" (a major store with large amounts of stock) and asked for a sacrificial anode to suit a Siebel Eltron WA300 Heat Pump hot water system.

The instruction manual for this heater says to check the sacrificial anode after 12 months – he's had it for nearly three years. And heat pumps cost far more to replace than conventional hot water systems!

The (usually quite knowledgable) girl behind the counter looked at him as if he was talking Swahili and turned to the other salesman to see if he knew what was being asked for. Blank looks abound! So they asked a plumber who was also being served at the time and he got this quizzical look on his face while shaking his head.

The girl then said "I'll have to ask Bob when he comes back from lunch and ring you back". Bob, as it turned out, was the manager of the place who had been a plumber most of his working life.

Apparently he asked "why would anyone want one of those?" but at least knew what a sacrificial anode was! The end result was that they couldn't locate one from any of their normal suppliers.

Our guy then rang the importers and was told that it was a bog-standard 1.2m "black top" anode and "anyone could sell you one of those". He told the bloke on the phone his tale of woe at the wholesalers, who responded with comments along the lines of what we said earlier in this article. "Plumbers don't replace them," he said, "but that could be because it's much more lucrative to replace a whole hot water system when it starts to leak."

If that's not an indictment of an industry, then what is?

But he was able to steer our guy in the right direction – "call Reece Plumbing Supplies," he said. They should be able to help you.

He was right – they could and did (although they had to order one in, as even then it was not a normal stock line).

And if you don't want to DIY?

If you do not want to do the job yourself, contact a local company who specialise in hot-water service, or even the manufacturer of your unit. Most have service departments.

But be prepared for a long silence when you tell them what you want!

DANGER: Hydrogen build-up in hot water tanks

When changing a sacrificial anode, or even when using a pressurised hot water system after a period of non-use (eg, returning from holidays) be careful of hydrogen build-up in the tank.

Hydrogen, a colourless and odourless (but highly explosive) gas, is released from the anode as part of the chemical reaction which allows it to protect the tank. In normal use it is eliminated from the tank by the flow of water (you may experience a sputter at times when you turn the hot water tap on).

Therefore this is not normally a problem when changing sacrificial anodes because you remove the pressure (and hydrogen gas) by turning on a hot tap and activating the pressure release valve but you should avoid smoking and also remove any other ignition sources before starting work.

The steps you need to replace your anode

[a] Check the specifications label on your tank. You need to know the anode type required (eg, black or blue; dependent on water quality) and the brand, model and size of tank. If the anode type is not listed, your supplier will need the other information to get the right one.

[b] Having obtained the required sacrificial anode, check that its length is about right for the tank; it must not be too long. If it touches the sides or bottom inside the tank, it can cause rapid corrosion – exactly what you *don't* want!

[c] Turn off the electricity supply at the switchboard by removing the hot-water fuse or switching off the relevant circuit breaker or main switch (or both).

[d] Turn off the water supply with the stop-cock on the cold water inlet.

[e] Release the pressure inside the tank by lifting the lever on the pressure relief valve near the top of the tank. Lift it gently and release it gently; do not let it snap back into place because that might damage the valve seat.

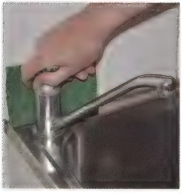
[f] Open one or more of the hot water taps in your home to bleed off a little water. Not much should come out.

[g] Remove the plastic inspection cover in centre of the top plate of the tank. You should see the black nut (typically 11/16 inch).

[h] Use the correct socket to loosen the nut. Do it slowly; just in case you did not do the preceding steps! No water should leak out.

[i] Before removing the old anode, check that its threaded section at the top is identical to the replacement anode. If it is not identical, you will need to re-install the old anode and get the correct replacement.

[j] OK. So is the old anode heavily corroded? If not, you may want to leave it for another year. Before screwing it back into place, remove the old Teflon tape from the threads and run a few turns of new tape around it to ensure a good seal. Do it up tight but not overly so. Remember that you will want to remove it in the future.



If the anode is heavily corroded, it should be replaced and if there is limited head-room, you will need to carefully bend it as you lift it out. Do not apply any leverage to the threaded section in the tank as you do this. Mind you, if the anode is heavily corroded there may not be much of it left so removing it should be easy.

[k] Now you need to insert the new anode. If you have a straight anode and no head-room limitation, you can just lower it into the tank. Note that some anodes will be supplied with Teflon tape already wound on to the threaded section. If this is not present, you must wind several turns of Teflon tape around thread, in the same directions as the thread. Almost invariably, that is clockwise.

If you have restricted head-room above the tank, you will need a flexible (ie, segmented) anode. It must be inserted into the tank so that when it is fully in, it is not touching the inside (of the tank). You do this by straightening each pair of segments as they are lowered into the tank. When you are sure that nothing is touching inside, tighten (but do not over-tighten) the nut.

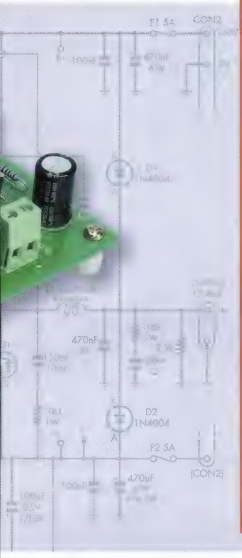
Then reverse the other steps of the removal process. That is, turn on the water supply to the tank, let the water run briefly from one or more the taps inside you house and then check that no water is seeping from around the top of the new anode. When everything is hunky-dory, snap the plastic inspection cover back into place and restore the electricity supply. **sc**

The CLASSIC-D

Pt.1: By John Clarke

World's first DIY high-power high-performance Class-D amplifier: 250Ω into 4Ω; 150W into 8Ω

You asked for it and now we are finally delivering it! Over the years we have worked on a number of Class-D amplifiers but they never saw the light of day because they were simply too difficult to build and were unreliable. We kept blowing 'em up! But now we have succeeded and as a bonus, this design has high power, very low harmonic distortion and is very quiet.



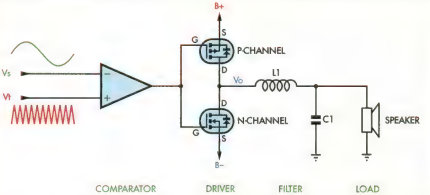


Fig.1: simplified circuit of a Class-D amplifier. The incoming analog waveform (Vs) is compared to a high-frequency triangle wave (Vt) and the comparator then drives a pair of Mosfets to generate a PWM waveform. This then passes through an LC low-pass filter before being delivered to the speaker.

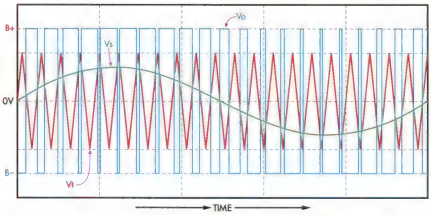


Fig.2: this diagram shows the two input waveforms fed to the circuit of Fig.1, along with the PWM output (V_O). Note how the duty cycle is longer when Vs is high and shorter when Vs is low. The output of the filter will be quite similar in shape to Vs.

CLASS-D OR SWITCHING amplifiers are made by the squillions and used in countless TV sets, home audio systems and a host of other applications ranging from iPod players and phones to large amplifiers in commercial applications. So they are obviously reliable when they are mass produced.

However, in the past when we have taken a typical Class-D chipset and tried to adapt it to a do-it-yourself design for publication in SILICON CHIP, we have been lamentably unsuccessful. Inevitably the chipsets were surface-mount devices and some employed quite critical heatsinking for the main amplifier itself. And inevitably again, we consistently blew devices as we tried to devise a reliable DIY design.

So much so, that Leo Simpson, the publisher of this magazine, had sworn off attempting another Class-D amplifier. Time heals all wounds though and eventually he relented when he saw the details and specs of this proposed design. Yes, it does use a surface-mount driver chip but the pin spacing is quite reasonable for hand-soldering. More particularly, the main switching Mosfets are conventional TO-220 devices that are easy to solder and heatsink. All the other components are conventional leaded devices and the result is that this Class-D amplifier is easy to assemble.

That's its first big advantage. Its second big advantage is ruggedness and reliability. It delivers heaps of power and has all sorts of protection built in so we have not blown up a succession of devices during development. Well, back up a minute, we did blow some in the early stages but those problems have all been sorted out.

Efficiency is the third big advantage, in common with all Class-D switching amplifiers. Typical efficiency is around 90% and that means that this amplifier will deliver considerably more power from a given power supply than would be possible with a typical linear amplifier such as our Ultra-LD design.

High-quality sound is the final advantage of this design and this is its outstanding feature. Most Class-D amplifiers are only average in this respect and this applies to the vast majority of sound equipment used in homes today.

We've christened the new module the CLASSiC-D. Why the CLASSiC-D moniker? Well, "CLASS" stands for class (what else?), "SiC" is for SILICON CHIP and "D" describes the class of operation.

What is Class-D?

So what is a Class-D amplifier and how does it differ from a conventional amplifier? Put simply, conventional audio amplifiers are either Class-A, Class-B or Class-AB (a combination

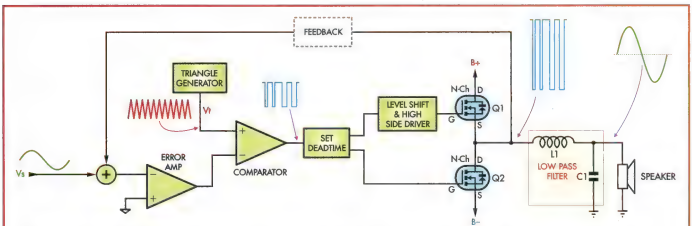


Fig.3: a more complete block diagram of a Class-D amplifier. This adds an error amplifier which provides some feedback from the output, reducing distortion. The output arrangement is improved too, with a pair of N-channel Mosfets. With this arrangement, the upper Mosfet must be driven from a floating gate supply and a dead-time generator is used to prevent cross-conduction which would otherwise waste power and increase dissipation.

of the first two). These amplifiers have their output driver transistors (or Mosfets) operating linearly and if you trace the signal through them, you will find that its shape is unchanged but increased in amplitude as it passes through successive stages to the output.

Class-D amplifiers operate in an entirely different mode whereby the output Mosfet or bipolar transistors operate as switches rather than in their linear region and are either fully switched on or fully switched off. When switched on (or off), the power losses within the Mosfets (or output transistors) are almost zero. Thus a Class-D amplifier is far more efficient and generates much less heat than linear Class-A, Class-B and Class-AB designs.

In a Class-D amplifier, the output devices are switched at a very high frequency and the duty cycle is varied by the input audio signal. This is called pulse width modulation (PWM). After filtering to remove the high-frequency switching from the output, the result is an amplified version of the input signal.

With Class-D it is often (mistakenly) assumed that "D" stands for digital. Not true. It was called Class-D because the previous amplifier classes were A, B, AB and C. So when switching amplifiers were first devised many decades ago, it was natural to call them Class-D.

Features

- High efficiency
- High power
- Low distortion and noise
- Bridging option for driving 8Ω loads with two modules
- Over-current protection
- Over-temperature protection
- Under-voltage switch-off
- Over-voltage switch-off
- DC offset protection
- Fault indicator
- Amplifier running indicator
- Optional speaker protector module

Class-D basics

Fig.1 shows the simplified arrangement of a Class-D amplifier. It consists of a comparator that drives a complementary Mosfet output stage with balanced supply rails (B+ and B-).

The comparator compares a fixed-frequency triangle wave against the incoming analog signal. Its output swings low, to B-, when the input signal voltage is more positive than the triangle waveform and swings high, to B+, when the signal voltage is below. The output stage shown here is inverting so the common drain (Vo) has the correct sense, ie, high when the input signal voltage is above the triangle voltage and vice versa.

Fig.2 shows the switching waveform produced by this circuit as well as the triangle wave input. The triangle wave (Vt) is at a much higher frequency than the input signal (Vs) and the resulting PWM output is shown as Vo.

A second order low-pass filter comprising inductor L1 and capacitor C1 converts the PWM signal to a smoothly varying voltage. The result is an amplified version of the input signal which is then applied to the loudspeaker, reproducing the input waveform as sound.

Fig.3 shows a more practical Class-D audio amplifier. This includes negative feedback from the PWM output to an error amplifier. The feedback reduces distortion at the amplifier's output and also allows a fixed gain to be applied. The input signal is applied to the error amplifier at the summing junction and its output is applied to the following comparator which acts in the same way as in Fig.1, comparing a triangle waveform with the error amplifier output.

Note that because feedback comes from before the LC filter, the filter must be very linear for the output distortion to be low. In other words, we are assuming that the output filter does not add much distortion since there is no feedback around it and therefore if it does, that distortion will not be automatically compensated for. We don't want to add feedback around the output filter because it introduces a significant phase shift to the signal and that would adversely affect amplifier stability.

Fig.3 employs two N-channel Mosfets and so the driving circuitry is more complicated. It includes a "dead-time" generator that prevents one Mosfet switching on before the other has switched off. Without dead-time, each time the output switches, there would be massive current flow as both Mosfets would simultaneously be in a state of partial conduction.

The Mosfet driver also includes a level shifter and high-side gate supply voltage generator, so that Mosfet Q1's gate can be driven with a higher voltage than its source (as is necessary to switch on an N-channel device). N-channel Mosfets are generally more efficient than P-channel types and since it can be the same type as Q2, the switching times are better matched.

It is important that Mosfets Q1 and Q2 have similar characteristics so that the switching and dead-time can be optimised. The desirable characteristics include low on-resistance ($R_{DS(ON)}$) for minimal dissipation, a low gate capacitance to reduce switching losses and minimise switching times, and low gate resistance and reverse recovery times. These allow for a fast switching speed with short dead-times. Increased dead-time generally means increased distortion, so the shorter the better.

In practice, our new Class-D amplifier works in a slightly different way to that depicted in Figs.1, 2 & 3 since it uses a scheme known as "second-order delta-sigma modulation". In this, the triangle wave is produced by an integrator which is connected as an oscillator and its frequency varies with the output duty cycle.

This integrator also effectively forms the error amplifier and as with the simpler scheme described above, its output is fed to the comparator which controls the Mosfets. In terms of actual circuit complexity, the delta-sigma scheme probably uses less components and from our tests, it gives surprisingly good performance. So it's a clear winner compared to the traditional approach explained above.

Full circuit details

Fig.4 shows the full circuit of the Silicon Chip CLASSiC-D Amplifier. It's based on an International Rectifier IRS2092S Class-D audio amplifier IC (IC1). This incorporates the necessary integrator, comparator, Mosfet drivers and fault protection logic.

It also includes the level shifting and high-side driver required for the two N-channel Mosfets (Q1 & Q2).

The over-current protection thresholds for each output Mosfet and the dead-time delay are set by external resistors on IC1's CSH, OC_{SET} and DT pins. The IC also has a fault input/output pin (C_{SD}) to allow external sensing of supply rail under-voltage and over-voltage conditions, as well as heatsink thermal limiting. This is used to shut down the amplifier if one of these fault conditions has occurred.

Other components in the circuit are included to regulate and filter the various power supplies, while inductor L1 and a 470nF capacitor form the low-pass output filter.

As shown on Fig.4, the main ±50V (nominal) supplies (B+ and B-) are fed in via fuses F1 and F2. These rails are then filtered by 470µF low-ESR capacitors that are bypassed with 100nF capacitors. The B+ rail connects to the drain of Mosfet Q1 while B- connects to the source of Q2 and to the common (COM) of IC1 at pin 10.

There is no direct B+ connection to IC1. Instead, the Vcc supply at pin 12 is relative to and derived from the B- supply via zener diode ZD1 and transistor Q3. In operation, current flows through ZD1 via a 7.5kΩ resistor (R9), so ZD1's cathode is at B- plus 15V. This voltage is buffered by Q3 and bypassed using 100µF and 1µF capacitors to derive the Vcc rail (ie, 15V above B-).

This voltage is applied to pin 12 of IC1 and is the supply rail for the low-side driver inside IC1. This drives Mosfet Q2's gate via the pin 11 (LO) output.

When pin 11 is low (ie, at COM or B-), Mosfet Q2 is off. Conversely, when the LO output goes high to Vcc, Q2's gate-source voltage is around +15V and so Q2 switches on.

Similarly, Q1's gate must be at least 12V above its source in order to switch it fully on. Its source is connected directly to the output inductor (L1) and this can swing up to B+ (or very close to this) when Q1 is on. Conversely, this side of the output inductor goes to B- when Q1 is off and Q2 is switched on.

This means that the voltage supply for Q1's gate drive must "float" on top of the output rail. Fig.5 shows a simplified version of the basic arrangement.

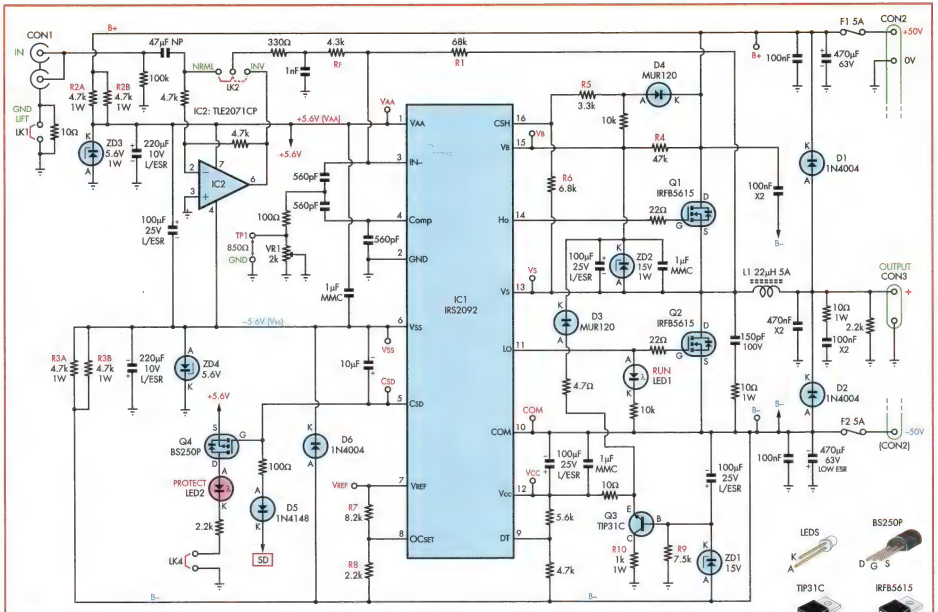
When the output at the junction of Q1 & Q2 is low, D3 is forward biased and this charges the 100µF and 1µF capacitors in parallel across ZD2 from the 15V Vcc supply. Conversely, when this output goes high, D3 is reverse biased but the two capacitors retain charge for long enough to keep Q1's gate high (via V_B and HO of IC1) and thus Q1 switched on until the next negative pulse.

When both Mosfets are switched off (eg, when power is first applied or during a fault condition), the voltage at Vs (pin 13 of IC1) is held near ground by current flowing through the speaker load at CON3 or, if no speaker is attached, the parallel 2.2kΩ resistor. Since D3 is reverse-biased in this condition, resistor R4 (47kΩ) is included to provide a small amount of current to keep the capacitors across ZD2 charged, so that Q1 can be quickly switched on once conditions have stabilised.

The current through R4 produces a small DC offset at the amplifier's output but it's not sufficient to cause

Specifications

THD+N: typically <0.01%; see Figs.8-10
Power output: up to 150W into 8Ω and 250W into 4Ω, depending on power supply
Power output, bridged, 8Ω only: 450-500W, depending on power supply
Efficiency: typically 90% at full power for 8Ω and 83% for 4Ω
Signal-to-noise ratio: 103dB with respect to full power
Input sensitivity: 2V RMS (4Ω), 2.2V RMS (8Ω)
Frequency response: ±1dB, 10Hz-20kHz
Power requirements: ±40-60VDC, 50-55V nominal
Over-temperature cut-out: 75°C
Under-voltage threshold: +40V
Over-voltage threshold: +75V
DC offset protection threshold: > ±4VDC
Over-current threshold: 29A
Idling (no signal) frequency: ~500kHz (adjustable)
Mosfet dead time: 45ns



SC 09072 CLASSIC-D AMPLIFIER

Fig.4: the main circuit for the CLASSiC-D Amplifier module (without the protection circuitry shown in Fig.6). It's based on IC1, an IRS2092 Digital Audio Amplifier which contains the error amplifier/triangle wave generator, comparator, dead time generator, level shifter, Mosfet drivers and protection logic. Op amp IC2 provides the signal invert option, while Mosfets Q1 & Q2 form the output stage. The main supply rails are B+, GND and B-, while IC1 has four additional supply rails: +5.6V (V_{AA}), -5.6V (V_{SS}), B- + 15V (V_{CC}) and a 15V floating supply (V_B/V_S).

any problems. With no load attached, the output offset will be +1.56V, due to current flowing through R4, ZD2 and the 2.2kΩ resistor at the output. This drops to 5.7mV with an 8Ω loudspeaker load (or half that for a 4Ω load).

Input circuit

The input/analog section of IC1 is powered from a pair of separate ±5.6V rails. These are connected to pin 1 (V_{AA}, +5.6V) and pin 6 (V_{SS}, -5.6V) and are referenced to GND (pin 2). They power IC1's internal error amplifier/integrator and comparator circuits and they also power op amp IC2.

The ±5.6V rails are derived from the main B+ and B- rails via paralleled 4.7kΩ resistors and zener diodes ZD3 and ZD4. A 220µF capacitor filters each supply, while a 100µF electrolytic and 1µF MMC capacitor in parallel bypass the total supply between V_{AA} and V_{SS}.

The amplifier's signal input is applied to one of the two RCA sockets at CON1 – one vertical, the other horizontal so that you have a choice when it comes to making the connection. Having a second input socket also allows the input signal to be daisy-chained to a second amplifier module if you want to operate two modules in bridge mode.

The RCA socket shields are either connected directly to ground via link LK1 or via a 10Ω resistor. This resistor is typically included in a multi-channel amplifier and prevents hum by reducing the current flowing between the signal ground connections. It can also improve channel separation.

As shown in Fig.4, the input signal is fed via a 47µF capacitor to jumper block LK2. This allows you to select whether the input is inverted by op amp IC2 or not. If you are using just one module, then LK2 would be installed in the normal (NRML) position.

The invert mode is useful for bridging two amplifier modules. In that case, the first module is set to normal mode and the second to invert. The same input signal is then fed to both amplifiers and the speaker connected between the two outputs.

Supply bus pumping

You can also use the invert mode for one channel of a stereo amplifier. Basically, it's a good idea to invert the output signal of one amplifier relative to the other. The correct phase is then maintained by swapping the output terminals of the inverted amplifier module. This prevents a problem with Class-D amplifiers whereby the power supply can be raised above its normal voltage by a process called "supply bus pumping".

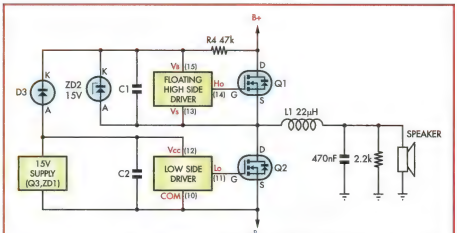


Fig.5: a simplified version of the floating supply arrangement. C1 is charged to 15V which is limited by ZD2. When the output (Vs) is low, C1 charges from C2 via D3. C1 partially discharges (due to gate drive current) when Vs is high and recharges on the next low cycle. R4 charges C1 when both Q1 and Q2 are switched off (eg, when power is first applied).

Supply bus pumping is caused by the energy stored in the inductance of the output filter and speaker winding(s) being fed back into the supply rail via the output Mosfets. This is primarily an issue for signal frequencies below 100Hz, ie, the ripple frequency of the main supply capacitors.

When one amplifier is driven out of phase to the other, the supply pumping effect is cancelled out, assuming the low-frequency signal is more or less evenly split between the two channels. In bridge mode, this is automatically the case so the effect doesn't occur.

From LK2, the signal is fed through a low-pass filter comprising a 330Ω resistor and 1nF capacitor which prevents RF signals from entering the amplifier. This filter also prevents high-frequency switching artefacts at the output from being feed back to the input via resistors R1 and R_F.

Following the low-pass filter, the audio signal is fed to the inverting input (IN-) at pin 3 of IC1. R_F (4.3kΩ) and R1 (68kΩ) set the gain of the amplifier, with feedback via the 68kΩ resistor also applied to the IN- input. The gain with the component values shown is 68kΩ ÷ (4.3kΩ + 330Ω) = 14.7 or 23dB.

The 560pF capacitor between the COMP input (pin 4) and GND (pin 2) rolls off the open loop gain of the amplifier, to ensure stability. Two more 560pF capacitors between the COMP and IN- pins, together with a 100Ω resistor and trimpot VR1, set the oscillator frequency. This RC network forms the second-order delta-sigma differentiator.

Output filter

The switching amplifier output is filtered using 22µH inductor L1 and a 470nF X2 polypropylene capacitor. The inductor is a special type chosen for its linearity, so as to minimise distortion, especially at higher frequencies.

This type of LC low-pass filter has second order characteristics, ie, after the -3dB point it rolls off at around 12dB/octave. The switching frequency is around 500kHz and the filter's -3dB point is set to $1 \div (2\pi \times \sqrt{(22\mu H \times 470nF)}) = 49.5kHz$. This gives $\log_2(500kHz \div 49.5kHz) \times 12dB + 3dB = 43dB$ attenuation of the nominally 50V RMS switching waveform.

Thus, we expect a high-frequency signal of about 0.4V RMS to remain after the filter – which is very close to that measured.

A snubber network comprising a 10Ω resistor and series 100nF capacitor is also connected across the output following the filter to prevent oscillation. Similarly, there is a 150pF/10Ω 1W snubber at the switching output to limit the rise and fall times and so reduce EMI (electromagnetic interfer-

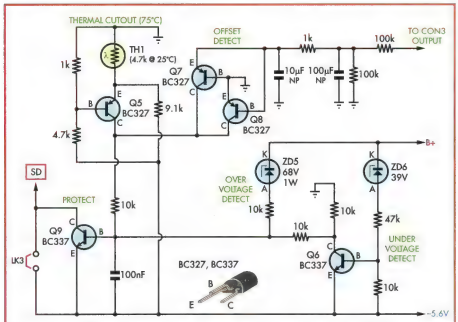


Fig.6: the additional protection circuitry on the amplifier PCB. TH1 provides over-temperature protection, ZD5, ZD6 & Q6 provide over and under-voltage protection, and Q7 & Q8 provide DC offset protection. If any of the fault conditions is met, Q9 turns on and pulls the C_{SD} pin of IC1 to -5.6V via D5 and a 100Ω series resistor (shown in Fig.4).

ence). D1 and D2 clamp any output excursions that would otherwise go beyond the B+ and B- supply rails (eg, due to the speaker coil inductance).

Fault protection

When power is first applied or if a fault occurs, the shutdown input (C_{SD}) at pin 5 is held at -5.6V (or close to it). In that case, Mosfets Q1 and Q2 are both off and switching is disabled. And with no gate drive for Q2, LED1 is off too.

IC1 is held in this state until the V_{AA}, V_{SS}, V_{CC} and V_B supplies reach sufficient voltage for it to operate.

In addition, IC1 can be shut down by external protection circuitry when its C_{SD} pin (pin 5) is pulled low via D5. The additional protection circuitry on the PCB is shown in Fig.6. When C_{SD} is low, P-channel small-signal Mosfet Q4 turns on and this lights LED2 (PROTECT), provided link LK4 is installed.

Shutdown also occurs if either Q1 or Q2 passes excessive current, eg, due to a shorted output. In operation, the output current is measured by monitoring the voltage across each Mosfet during the period it is switched on. The Mosfets specified (IRFB5615) have a typical on-resistance of 35mΩ at 25°C.

In the case of Q2, the current threshold before shutdown is set by resistors R7 and R8, at pins 7 and 8 of IC1. Pin 7 is the reference (5.1V), while pin 8 (OCSET) is the over-current threshold input. This is set at 1.08V by the 8.2kΩ and 2.2kΩ resistors and this in turn sets the current shutdown at about 30.8A (ie, 1.08V ÷ 0.035Ω) at 25°C (or slightly less as Q2's temperature rises during operation).

The high-side current limit is set by divider resistors R5 and R6 on IC1's CSH input (pin 16). This circuit works in a different manner to the low-side current limiting circuit. In this case, diode D4 provides a reference voltage that's about 0.6V above B+. That's because V_B is 15V above B+ and is applied to D4's anode via a 10kΩ resistor.

This reference voltage is applied to the top of the divider, the bottom end of which goes to the Vs rail (pin 13). As the current through Q1 increases, so does the voltage across it and so V_S drops in relation to B+. As a result, the voltage at the CSH pin rises relative to V_S until there is about 1V across Q1, at which point the over-current protection kicks in (for more detail on this, refer to International Rectifier application note AN-1138 at **www.irf.com/technical-info/appnotes/an-1138.pdf**).

The dead time for Q1 and Q2 (ie, the delay between one switching off and the other switching on) is set by the two divider resistors (5.6kΩ/4.7kΩ) on DT (pin 9). For this design, it is set at 45ns, the second-fastest option out of four.

More protection

Additional protection circuitry (see Fig.6) is used to prevent the amplifier from running should it overheat or develop a large DC offset, or if the supply voltage goes outside the normal operating limits. In any of these events, transistor Q9 switches on and pulls IC1's CSD input low via diode D5 and a series 100Ω resistor.

Jumper link LK3 provides forced shut-down of the amplifier. It's there to allow the supply voltages to be checked after construction, before the amplifier is allowed to run. Once the supplies have been checked out, LK3 is removed.

The over-temperature cut-out is provided using thermistor TH1. This thermistor has a resistance of 4.7kΩ at 25°C, dropping to about 690Ω at 75°C.

Thermistor TH1 is monitored by transistor Q5. This transistor's base is biased to 982mV below ground (ie, -5.6V x 1kΩ ÷ (4.7kΩ + 1kΩ)), while its emitter is 1.9V below ground with TH1 at room temperature.

Q5's emitter will rise to 0.6V above its base when TH1's resistance drops to 690Ω, ie, when TH1's temperature rises above a critical point. At that point, Q5 switches on and supplies current to Q9's base via a 10kΩ current-limiting resistor, thereby turning on Q9 and shutting down the amplifier.

Q6 and ZD6 make up the under-voltage detection circuit. If the supply voltage drops much below 40V, ZD6 no longer conducts and Q6 turns off. This allows current to flow into Q9's base via the 10kΩ pull-up resistor and a further 10kΩ series resistor and so Q9 turns on and shuts the amplifier down.

By contrast, the over-voltage protection kicks in at around 60V, when ZD5 begins to conduct. This again supplies current to Q9's base to shut the amplifier down.

DC offset protection

Q7 and Q8 monitor the amplifier's output DC offset. As shown, the amplifier's output is fed through a low-pass RC filter consisting of two 100kΩ resistors and a 100µF NP capacitor, to remove frequencies above 0.3Hz. This

Parts List: CLASSiC-D Amplifier

1 PCB, code 01108121, 117 x 167mm
1 heatsink, 100 x 33 x 30mm (eg, Jaycar HH-8566, Altronics H0560A cut to 30mm)
1 22µH 5A inductor (L1) (ICE Components 1D17A-220M [X-ON, Mouser] or Sagami 7G17A-220MR)
1 chassis-mount 45° 6.4mm single spade terminal (to secure TH1)
3 TO-220 insulating washers & bushes
1 solder lug
4 M205 PCB-mount fuse clips
1 NTC thermistor 4.7kΩ at 25°C (TH1)
2 5A fast blow M205 fuses (F1,F2)
1 vertical PCB-mount RCA socket (Altronics P0131) (CON1) and/or
1 horizontal PCB-mount RCA socket (Jaycar PS-0279) (CON1)
1 3-way PCB mount screw terminal (5.08mm pin spacing) (CON2)
1 2-way PCB mount screw terminal (5.08mm pin spacing) (CON3)
2 2-way pin headers (2.5mm spacing) (LK1,LK3)
1 3-way pin header (2.5mm spacing) (LK2)
1 polarised 2-way header (2.54mm spacing) (LK4)
2 3/8-inch x 20mm-long machine screws (to secure heatsink to PCB)
5 M3 x 10mm machine screws
11 PC stakes
1 50mm length of 0.7mm tinned copper wire
4 jumper shunts (shorting links)
4 M3 x 9mm tapped Nylon spacers
4 M3 x 5mm machine screws
1 8-pin DIL IC socket
1 25-turn 2kΩ trimpot (VR1)

Semiconductors

1 IRS2092S Digital Audio Amplifier IC [SOIC-16] (IC1)*
1 TLE2071CP op amp (IC2)*
2 IRFB5615 150V 25A N-channel digital audio Mosfets (Q1,Q2)*
1 TIP31C NPN transistor (Q3)
1 BS250P P-channel DMOS FET (Q4)
3 BC327 PNP transistors (Q5,Q7,Q8)
2 BC337 NPN transistors (Q6,Q9)
1 3mm blue LED (LED1)
1 3mm red LED (LED2)
3 1N4004 1A diodes (D1,D2,D6)
2 MUR120 super-fast diodes (D3,D4)
1 1N4148 diode (D5)
2 15V 1W zener diodes (ZD1,ZD2)
2 5.6V 1W zener diodes (ZD3,ZD4)
1 68V 1W zener diode (ZD5)
1 39V 1W zener diode (ZD6)

Capacitors

2 470µF 63V or 100V low-ESR PCB-mount electrolytic
1 100µF 50V non-polarised PCB-mount electrolytic
2 220µF 10V low-ESR electrolytic
4 100µF 25V low-ESR electrolytic
1 47µF 50V non-polarised PCB-mount electrolytic
1 10µF 16V PCB-mount electrolytic
1 10µF non-polarised PCB-mount electrolytic
3 1µF MMC
1 470nF 250VAC X2 MKP
2 100nF 250VAC X2 MKP
3 100nF 100V MKT
1 1nF 100V MKT
3 560pF MKT (Rockby 35636 or 32733) (supplied with PCB)
1 150pF 100V (minimum) ceramic or MKT

Resistors (0.25W, 1%)

3 100kΩ
1 68kΩ (R1)
1 47kΩ (R4)
1 47kΩ
7 10kΩ
1 9.1kΩ
1 8.2kΩ (R7)
1 7.5kΩ (R9)
1 6.8kΩ (R6)
1 5.6kΩ
4 4.7kΩ
4 4.7kΩ 1W 5% (R2A, R2B, R3A, R3B)
1 4.3kΩ (Rf)
1 3.3kΩ (R5)
2 2.2kΩ
1 2.2kΩ (R8)
1 1kΩ 1W 5% (R10)
2 1kΩ
1 330Ω
2 100Ω
2 22Ω
2 10Ω 1W 5%
2 10Ω
1 4.7Ω

Speaker Protector

1 PCB, code 01108122, 76 x 66mm
2 5-way PCB-mount screw terminal block or 2 x 2-way and 2 x 3-way (CON1,CON2)
2 polarised 2-way headers (2.54mm pitch) (Input1 & Input2)
1 DPDT 24V 10A PCB-mount relay (RLY1) (Altronics S4313)
1 200mm length of medium-duty red hookup wire
1 200mm length of medium-duty black hookup wire
4 M3 x 9mm tapped Nylon spacers
4 M3 x 5mm machine screws

Semiconductors

2 4N28 optocouplers (OPTO1, OPTO2)
1 STP16NE06 Mosfet (Q10)
2 1N4148 diodes (D6,D7)
1 1N4004 diode (D8)
1 15V 1W zener diode (ZD7)
1 3mm red LED (LED3)

Capacitors

1 4.7µF 16V PC electrolytic

Resistors (0.25W, 1%)

1 1MΩ
1 100kΩ
1 10kΩ
1 4.7kΩ 1W
3 1kΩ
1 820Ω 5W
1 22Ω

** These parts are available from element14, Mouser and Digi-Key*

prevents normal AC signal excursions from tripping the circuit.

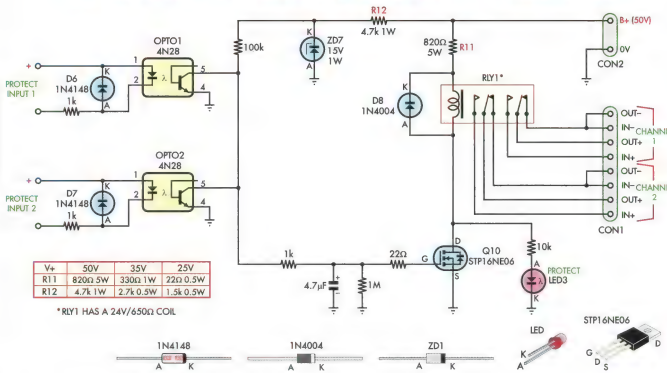
A second filter consisting of a 1kΩ resistor and 10µF capacitor follows. This is required to prevent false triggering due to high-frequency signals finding their way into Q7 and Q8.

If the amplifier's output has a positive DC offset, Q7's emitter is pulled 0.6V above its base (ground). As a result, Q7 turns on and so Q9 also turns on and the amplifier shuts down as before. Similarly, for a negative DC offset, Q8's base is pulled 0.6V below its emitter and Q8 and Q9 turn on.

Speaker protector

Note that even though IC1 turns off

CLASSiC-D Loudspeaker Protector



V+	50V	35V	25V
R11	820Ω 5W	330Ω 1W	220Ω 0.5W
R12	4.7k 1W	2.7k 0.5W	1.5k 0.5W

*RLY1 HAS A 24V/650Ω COIL

SC CLASSIC-D AMPLIFIER – SPEAKER PROTECTOR

Fig.7: the CLASSiC-D speaker protection circuit suits mono, stereo or bridged mono amplifiers. If either fault input is triggered, it pulls the gate of Q10 low via its associated optocoupler and 1kΩ resistor. This turns off RLY1, disconnecting the speaker(s) and lights LED3. Once the fault(s) clear, Q10 turns on after a delay, switching RLY1 on (and LED3 off) and connecting the speaker(s) to the amplifier module(s).

THE SPEAKER PROTECTOR makes use of the fact that whenever the amplifier is in protection mode, the Protect LED (LED2) is lit. By monitoring this, the protector circuit can disconnect the speaker from the amplifier whenever LED2 lights up. Since there is a delay after power-up before LED2 turns off and since it turns back on for a short time when you switch the unit off, it also provides a "de-thump" feature.

Fig.7 shows the stereo speaker protector circuit. For each module, an optocoupler (OPTO1 & OPTO2) connects in series with the protect LED of each amplifier module via LK4, which acts as a connector. When the protect LED turns on, the relevant optocoupler LED is also lit and this switches on the internal phototransistor.

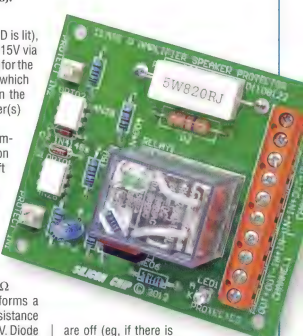
This in turn pulls the gate of Mosfet Q10 low via a 1kΩ resistor and 22Ω gate resistor. As a result, Q10 turns off and this turns the relay off, opening its COM and NO contacts and disconnecting the speaker from the amplifier.

Conversely, if both phototransistors are off (ie, no amplifier protect LED is lit), Mosfet Q10's gate is pulled up to 15V via a 100kΩ resistor. It takes about 4s for the 47µF capacitor to charge, after which Q10 turns on. This then turns on the relay which connects the speaker(s) to the amplifier module(s).

Note that if there is only one amplifier module, the second input on the Loudspeaker Protector is left unconnected.

The +15V supply rail for the optocouplers is derived from the B+ rail using 15V zener diode ZD7 and a 4.7kΩ 1W current-limiting resistor. By contrast, the 24V relay coil is powered from the 50V supply via an 820Ω dropping resistor. This resistor forms a voltage divider with RLY1's coil resistance to limit the coil voltage to about 24V. Diode D8 is included to quench any back-EMF spikes that may be generated when the relay switches off.

LED3 turns on when Q10 and the relay are off (eg, if there is a fault condition). Conversely, when Q10 and the relay are on, there is virtually no voltage across LED3 and it turns off.



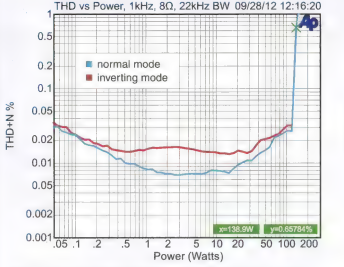


Fig.8: THD+N plotted against power level into an 8Ω resistive load. The power supply was set at ±55V and we used an Audio Precision AUX-0025 Switching Amplifier Measurement Filter in addition to a 20Hz-22kHz bandpass filter in the Audio Precision System Two.

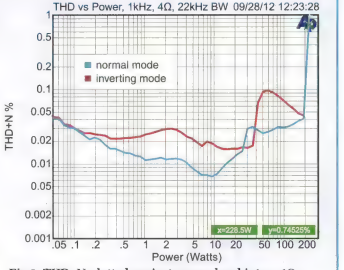


Fig.9: THD+N plotted against power level into a 4Ω resistive load (conditions otherwise identical to Fig.8). Note that in both cases, there is higher distortion across most of the audio band in inverting mode compared to normal mode. This is due to op amp IC2.

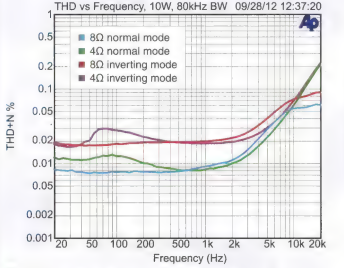


Fig.10: distortion versus frequency at 10W for 4Ω and 8Ω loads. As you would expect, distortion increases above the baseline for frequencies above about 1kHz. The 8Ω performance is better than 4Ω below 600Hz and above 10kHz but they are quite similar otherwise.

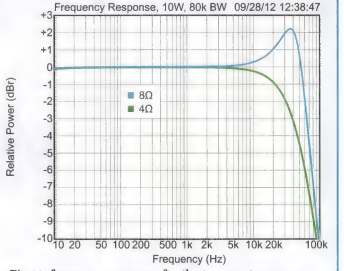


Fig.11: frequency response for the two most common load impedances. The input signal level and reference level is identical for both plots so this also demonstrates the relatively low output impedance of the amplifier. The difference is due to the output LC filter.

its driver outputs should a significant DC offset occur, this will not necessarily save the connected loudspeaker. That's because if one of the output Mosfets fails and goes short circuit, IC1 will be unable to turn it off and the full supply voltage will be applied to the loudspeaker, causing its voice coil to overheat and possibly catch fire.

To deal with this possibility, we have produced an additional small PCB which acts in conjunction with one or two CLASSiC-D amplifier modules to protect the speaker(s), even if an output Mosfet fails. It uses a relay to break the connection between the failed module and the speaker.

The speaker protector circuit and its operation are described in the panel on the previous page (see Fig.7).

Power supply

The CLASSiC-D amplifier module is designed to operate from nominal ±50V supply rails but will operate over the range of ±40-60V. For testing, we used the Ultra-LD Mk.3 Power Supply, as described in the September 2011 issue. This uses a 300VA 40V-0-40V toroidal transformer, a 35A bridge rectifier and 15,000μF filter capacitor banks across each rail.

While this has a nominal output of ±57V, it's perfectly suitable for use with this amplifier module and will give higher output power than from a ±50V supply. A supply of ±57V will give an output power of about 150W into 8Ω and 250W into 4Ω with 1% THD + N. On the other hand, you could quite easily substitute a 35V-0-35V transformer (which is a bit easier to obtain) to get close to ±50V from the same supply module with slightly reduced output power.

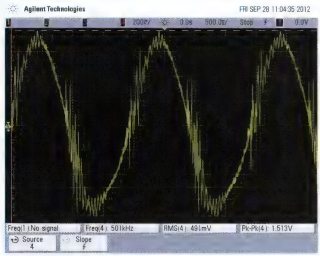


Fig.12: output waveform at idle (ie, no signal applied). This shows the switching frequency of around 500kHz and the residual amplitude of about 0.5V RMS. Note that the filter has converted the square-wave output into something resembling a sinewave.

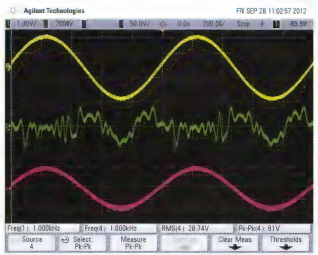


Fig.13: the filtered output of the amplifier (yellow, top) along with the distortion residual (green) at 100W into 8Ω (THD+N 0.026%). The red trace shows the output of the amplifier after the LC filter but with no additional filtering; you can just see the high frequency "fuzz".

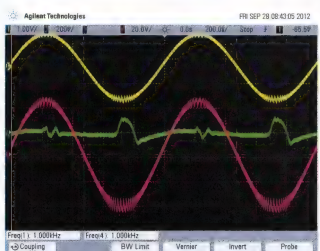


Fig.14: clipping behaviour at >230W into 4Ω (±55V) Note how the self-oscillation frequency drops at the output extremes and so the output tends to "bounce" off the rails when driven this hard. The distortion waveform is shown in green and is quite similar to that of a Class-AB design.

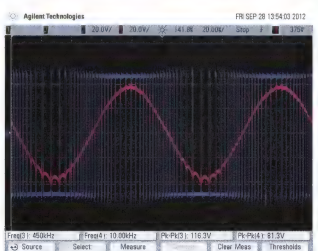


Fig.15: this scope grab shows the switching output of the amplifier with a 10kHz sinewave input (blue) and the reconstructed waveform after the LC low-pass filter (red). Again note how the frequency shifts as the duty cycle changes, with it being highest around the zero crossing.

We wouldn't go any higher than ±57V. The filter capacitors on the CLASSiC-D amplifier module are only rated for 63V (like the capacitors in the Ultra-LD Mk.3 Power Supply) and due to mains voltage variations, they may already operate close to that limit with a 40V-0-40V transformer.

If you want to build two (or four!) modules into one case, you can have them share a single power supply although that will reduce the continuous output power available (more so with 4Ω loads than 8Ω loads). It won't affect the music power much though.

Alternatively, you can use separate power supplies or a bigger transformer with a larger filter capacitor bank. For example, if you want to bridge two CLASSiC-D modules to get 500W into 8Ω and run them off a single power supply, you will need a transformer rated at 500VA or more.

If you want to run the module from a lower voltage supply, you can do so but it will deliver less power. In addition, several components need to be changed if the supply voltage will be below 40V (more on this in Pt.2 next month).

That's all for now. Next month, we will present the two PCB overlays and give details on how to build, set-up and test the amplifier module.

References & links

(1). IR Application Note AN-1138 (IRS-2092S) – **www.irf.com/technical-info/appnotes/an-1138.pdf**

(2). IRS2092 Data – **www.irf.com/product-info/datasheets/data/irs2092.pdf**

(3). Introduction to Electroacoustics and Audio Amplifier Design, Second Edition – **http://users.ece.gatech.edu/mleach/ece4435/f01/ClassD2.pdf**

(4). AN-1071 Class D Amplifier Basics – **www.irf.com/technical-info/appnotes/an-1071.pdf** SC

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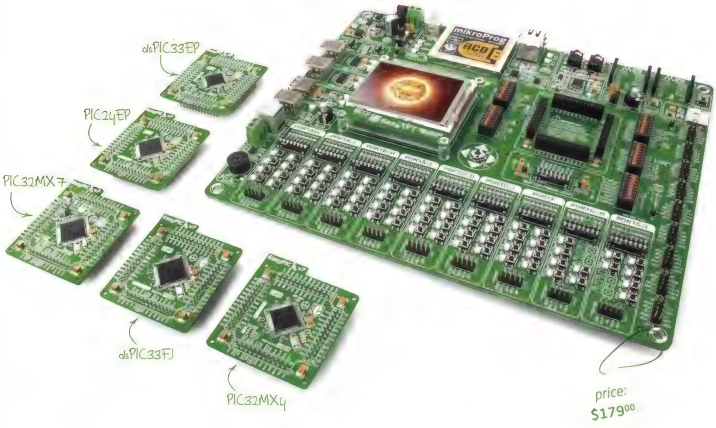

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High-Energy Electronic Ignition System

This new circuit improves upon our very popular high energy electronic ignition system. It uses an IGBT ignition driver rather than the expensive high-voltage Darlington used in our previous designs. You can use it to replace a failed ignition module or to upgrade a mechanical ignition system when restoring a vehicle.

IT'S HAPPENED TO many of us – one day you are driving around in a perfectly serviceable if older vehicle and then it quits on you, or it simply won't start the next morning. You take it to your local friendly mechanic who tells you that the ignition module has failed and will need to be replaced but because of the age of the vehicle (and possibly its overseas origin) the repair job will cost you many hundreds of dollars.

But because you are a SILICON CHIP reader you have a big advantage; you can build this substitute module for a fraction of the cost. Or maybe you have an older vehicle which has the old points ignition and you want to upgrade it to electronic ignition. Once again, our new module is the answer.

This new high-energy ignition suits vehicles with points, Hall effect/Lumenition sensors, optical sensors (eg, Crane & Piranha) and reluctor pick-ups. In fact, it will work with virtually any ignition system that uses a single coil, even those controlled by an engine management computer.

Better & simpler

We've improved on our previous 2005 design in a number of important ways. The main change is the use of an IGBT (insulated gate bipolar transistor) ignition driver. This features integrated protection and is the type of device used in virtually all new cars.

The Darlington transistor used in the older design was not only larger and more expensive but required a string of zener diodes to protect it against the high-voltage back-EMF from the ignition coil. Plus it required extra driving circuitry, some of which was bulky, that the IGBT simply does not need. The resulting much smaller module will be much easier to install, especially in motorcycles.

We have also built a self-test feature into this unit which means you can do a bench test to check it's working

Features

- Multiple trigger source options
- Trigger invert option
- Adjustable dwell time
- Option for output to follow input
- Spark test mode
- Tachometer output
- Adjustable debounce period
- Dwell compensation for battery voltage
- Simplified design using ignition IGBT to switch the coil
- Coil switch-off with no trigger signal

without needing a signal source to drive it with. Similarly, it can be used as a stand-alone ignition coil tester.

As with the High-Energy Ignition System from the December 2005 and January 2006 issues, this one also uses a PIC16F88 microcontroller as the "smarts" but naturally we have also improved the software.

Advantages of the IGBT

Our previous electronic ignition designs all utilised a Darlington transistor to switch the ignition coil. Both the BU941P and the MJH10012 have been used in the past and both are high-voltage transistors specifically intended for use in automobile ignition systems. But that approach has been obsolete for some time and all new cars now use IGBT ignition drivers. It enables a much simpler circuit.

Our previous Darlington circuits were similar to that shown in Fig.1(a) below. The 100Ω 5W resistor provides 120mA of base drive to ensure that the Darlington transistor switches on fully, ie, it is saturated. Transistor Q2 is driven from a 5V signal and when on, shunts Q1's base drive to ground to switch it off. Q1 also required a series of four 75V zener diodes to clamp the coil voltage to about 300V (to protect the transistor).

With an IGBT coil driver (Fig.1(b)), none of this extra circuitry is required. The IGBT is effectively a cross between a transistor and a Mosfet (a hybrid, if you like). Like a Mosfet, it is easy to drive from a voltage source but it has the high-voltage performance of a bipolar transistor and is capable of switching the inductive load of the ignition coil.

Like a logic-level N-channel Mosfet, it is switched on when 5V is applied to its gate terminal via the 1kΩ resistor, while a low gate voltage switches it off.

The zener diodes are no longer necessary because this type of IGBT incorporates internal voltage clamping to protect both the gate and the collector. When the collector voltage exceeds about 360V, an internal zener diode conducts and switches the IGBT on to shunt the current to ground. The gate is protected from over-voltage with internal back-to-back zener diodes.

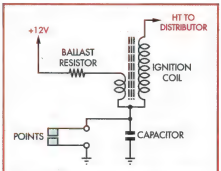


Fig.2: the Kettering ignition system uses points to interrupt the current through a coil. When the points open, the coil's magnetic field collapses and this produces a high voltage in the secondary which is fed to the spark plugs via the distributor and the plug leads.

Kettering system

Fig.2 shows the arrangement for a Kettering ignition, which is the good old-fashioned points system. It comprises points (operated by a cam in the distributor), a capacitor (also known as the "condenser"), an ignition coil and a distributor.

The primary winding of the ignition coil is connected to the +12V supply and when the points are closed, current flows through the coil, causing en-

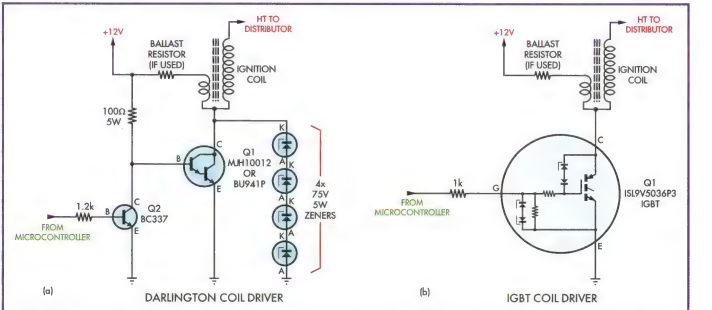


Fig.1: most cars of the last 20 years use an electronic trigger pick-up and an engine management computer to drive an electronic power device to switch the ignition coil on and off. Our previous designs used a Darlington transistor to switch the ignition coil as shown at (a) while our latest design uses an IGBT ignition coil driver to do the job (b). The IGBT has in-built protection and this greatly reduces the parts count, increases reliability and simplifies construction.

Specifications

Debounce: 166µs to 5ms in 30 steps

Dwell: 129µs to 26ms in 200 steps (graded for more resolution at the lower values) for signals above 3.125Hz. Below 3.125Hz, the dwell automatically increases to the full period between firing minus the 1ms spark period.

Latency from trigger edge to firing: 18µs (10µs due to the IGBT response time)

Spark test rate: 15-75Hz (adjusted using trimpot VR2)

Spark test dwell: 129µs to 26ms (no dwell extension with battery voltage included)

Coil switch-off delay: after 10s with no trigger signal for debounce period above 2ms; after 1s for debounce period below 2ms

Dwell extension with battery: progressively increases from 2x below 12V through to 4x at 7.2V supply and below

Spark period: 1ms minimum

Maximum RPM for 1ms debounce and 1ms spark: 15,000 RPM for 4-cylinder, 10,000 RPM for 6-cylinder and 7500 RPM for 8-cylinder engine (4-stroke)

ergy to be stored in its magnetic field. This field collapses when the points open, generating a high voltage. The coil secondary has many more turns than the primary and so it produces a higher voltage again, creating a spark across the spark plugs in the engine.

The capacitor is there to prevent unnecessary arcing across the points which would otherwise quickly become pitted and worn. Even so, there will always be some contact damage to the points due to sparking and so they need to be replaced on a regular basis – unless, that is, you install our electronic ignition module.

The coil charge period and the spark duration is set by the points opening and closing periods. These are determined by the distributor cam lobe design and the points gap setting. During the dwell period, the points are closed to charge the coil. This dwell period reduces as RPM increases and so at high RPMs, spark energy can drop off badly as the coil does not have sufficient time to fully charge between each spark.

Refinements to the Kettering system allow the ignition timing to vary with RPM and manifold vacuum (ie, engine load). The RPM advance uses a system of centrifugal weights that move outward with higher rotational speed. These weights then advance the position of the cam and its lobes relative to the distributor drive shaft from the motor.

To vary the spark with engine load, a vacuum-driven actuator can rotate the points relative to the camshaft to produce timing changes with varying manifold pressure.

When starting the engine, the high starter motor current draw drops the battery voltage, reducing the spark voltage. This effect is worst right when maximum spark energy is needed; especially starting in cold weather. To solve this problem, the ignition coil is designed to deliver a healthy spark even with a ballast resistor connected in series with the 12V supply. During starting, the ballast resistor is shorted out to increase the coil current drive and thus maintain sufficient spark energy.

Electronic ignition

Adding a switching transistor to a Kettering ignition system has many advantages. The main one is that the points no longer need to carry a high current – only enough to switch the transistor (and to keep the points clean). This minimises points wear, so that the only significant wear is to the rubbing block. That wear is insignificant and so the engine doesn't need to be re-tuned anywhere near as often.

Alternatively, the points can be replaced by Hall Effect, reluctor or optical triggering, thereby reducing ignition system maintenance to virtually nothing.

A secondary advantage of electronic ignition is that the dwell and spark duration are much more consistent, giving smoother engine running. The effect of reduced spark energy at higher RPM can also be alleviated, since with the electronic ignition module, coil charging can begin immediately after spark firing if necessary and the spark period can be kept low (1ms).

Features

Note that this particular design does not incorporate programmable timing. Instead, it utilises the existing timing advance curve that is incorporated into the distributor. If you need a programmable electronic ignition system, we published a suitable design in the March, April & June 2007 issues.

This new unit includes an adjustable debounce period, adjustable dwell time and increased dwell with low battery voltage. It also features a special "follow" operational mode for points if the distributor shaft, points cam and points are badly worn (more on this later). In addition, there is a spark test facility which allows the dwell to be easily adjusted to suit the ignition coil in use.

The spark test feature also allows an ignition coil to be tested on the bench over a range of spark frequencies.

During normal operation, the ignition coil is switched on for a sufficient dwell period just before firing. This allows the coil to charge fully without consuming any more power than necessary or overheating due to high saturation current. If the engine RPM becomes so high that the dwell period cannot fit between successive firings of the coil, the dwell period is reduced. The firing period is a minimum of 1ms, sufficient for the coil to deliver a healthy spark.

Dwell time

The dwell can be set between 129µs and 26ms in 200 steps, with more resolution available for the shorter periods. Some coils require a minimum 4ms dwell while high-performance sports coils need less. The spark test feature basically allows the dwell to be adjusted to its optimal value whilst watching the spark delivered from the coil across a spark plug gap.

The dwell time is automatically extended when the battery voltage falls below 12V, to compensate for the longer charging period required. This helps maintain spark energy when starting the engine. This is disabled in the spark test mode.

Another important feature with this electronic ignition module is that the coil is not energised until after the engine has begun to turn. This prevents

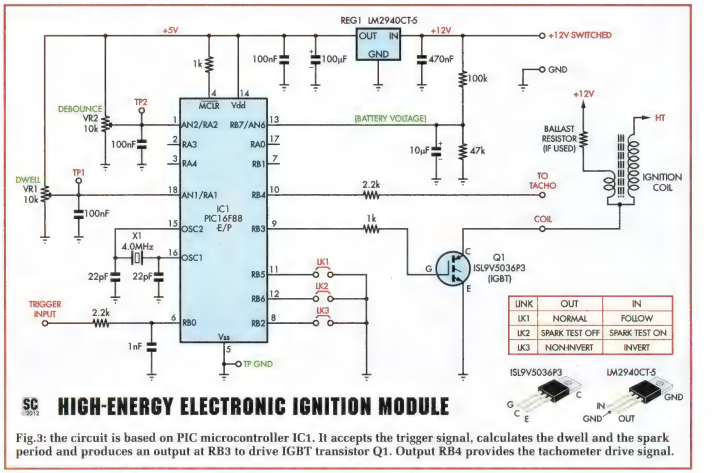


Fig.3: the circuit is based on PIC microcontroller IC1. It accepts the trigger signal, calculates the dwell and the spark period and produces an output at RB3 to drive IGBT transistor Q1. Output RB4 provides the tachometer drive signal.

the coil from overheating and possibly burning out when the ignition is first switched on but the engine is not turning over (ie, not being cranked). Also, if the engine stops with the ignition still switched on, the coil is automatically switched off after one second.

However, this one-second period could be too short for a single-cylinder motorcycle engine to start when kick-starting. To solve this, if the debounce setting is more than 2ms, the coil switch-off delay is increased to 10s. In this case, the ignition coil must be able to withstand the application of 12V for 10 seconds. Most coils designed for use with points are suitable as they are designed to cope if the motor stops with the points closed.

Debounce is included to prevent the ignition from being re-triggered due to noise on the trigger input. A 0.5ms period can be used with most sensor types but a longer period is needed for points as they do not tend to open or close cleanly. Instead, points can bounce back open after closing and this can result in a series of rapid openings and closings.

The debounce feature enables the circuit to ignore this. However, there is a limit to the length of this debounce period. If it is made too long, then the upper RPM range can be severely limited as the time between plug firings approaches the debounce period.

A 2ms debounce period for a single-cylinder engine will not present such a problem. In fact, the upper RPM limit with a 5ms debounce period and a 1ms spark duration is 20,000 RPM for a single-cylinder 4-stroke engine.

Follow mode

In order to cope with severe points bounce, we have provided a "follow" mode. When this mode is selected, the ignition system's output simply follows the input. This means that the coil begins charging as soon as the points close and the spark duration is not limited to 1ms.

In other words, much of the internal "smarts" which attempt to optimise coil charging are disabled in the follow mode. However, the debounce setting is still effective, to prevent false triggering.

Note that the follow mode should only be selected when using points that produce erratic firing with the normal setting.

Finally, the system also includes an option to invert the input sense, so that the coil can fire on either the rising or falling edge of the input signal. For points, coil firing always occurs when the points open (ie, on the rising edge). However, for other triggers, you may need to fire on either the rising edge or the falling edge.

Circuit description

Refer now to Fig.3 for the main section of the High-Energy Electronic Ignition circuit. The various trigger section options are shown in Fig.4.

Microcontroller IC1 is at the heart of the circuit. As shown, the trigger signal is applied to its pin 6 input (RB0). IC1 then processes this trigger signal and produces an output signal to drive the IGBT (Q1) at pin 9 (RB3).

The pin 6 input is protected from voltage spikes by a 2.2kΩ resistor. This limits the current if the internal clamping diodes between the input and each supply rail conduct. The associated 1nF capacitor provides high-frequency filtering to prevent false triggering.

Restoring An Older Vehicle

Ignition systems for cars and motorcycles have improved greatly over recent years, with increased spark energy across the entire rev range of the engine. Much of this improvement has been achieved by using separate ignition coils for each spark plug. The "old-fashioned" single coil and distributor is now rapidly becoming a relic.

But some older cars and motorcycles have a particular appeal and many are still in regular use. Enthusiasts often claim that these vehicles have more "personality" and are more "fun" to drive than modern counterparts.

So restoring an older vehicle to its former glory has a certain appeal. Commonly restored cars include the original VW Beetle and Kombi vans with air-cooled horizontal engines, early model Holden, Ford and Leyland vehicles, and classic marques such as MG, Morgan, Ferrari, Lancia, Citroen, Jaguar, Porsche and others

Similarly, motorcycle enthusiasts revere the Norton Commando, Triumphs, BMWs, Moto Guzzis, Ducatis, Indians and Harley Davidsons, etc. Many of these companies are still in business but their older models are still popular.

Almost invariably, these older cars and motorcycles utilise a Kettering ignition system, ie, one that comprises points, an ignition coil and distributor as shown in Fig.1. This type of system can usually benefit greatly with the addition of an electronic ignition module and that's where this unit comes into play.

Note, however, that this ignition module is not suitable for use with, or as a replacement for, a magneto ignition or a capacitor discharge ignition (CDI). These are found on some older motorcycles and in particular 2-strokes. To cater for these units, we published a replacement CDI module in the May 2008 issue of SILICON CHIP. This design utilises the high voltage generated by the vehicle's magneto to charge a capacitor. That charge is then dumped into the spark plugs via the ignition coil when triggered.

In operation, IC1's RB3 output is alternatively switched high to +5V to turn on Q1 and charge the coil, then to 0V in order to turn off Q1 and fire the spark plug when required. In addition, a second output is made available at RB4 (pin 10). This produces a 5V square-wave to drive to a suitable tachometer via a 2.2kΩ resistor. Note, however, that an impulse tachometer will usually be connected to the ignition coil instead.

In order to correctly process the trigger signal, IC1 monitors three separate voltages. The first is the battery voltage, at the AN6 input (pin 13). The battery voltage is first divided by 3.13 by the 100kΩ and 47kΩ resistors and filtered by a 10µF capacitor. The resulting voltage is then converted to a digital value using the micro's internal ADC and this is used to adjust the dwell time with low battery voltages.

The dwell and debounce periods are set using trimpots VR1 and VR2, each connected across the 5V supply. VR1 (dwell) and is monitored by input AN1 (pin 18), while VR2 (debounce) is monitored by input AN2 (pin 1).

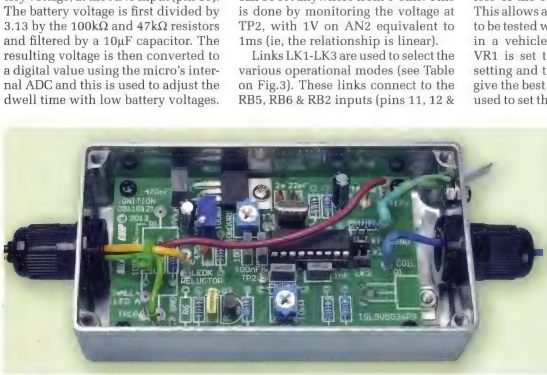
The dwell is adjustable from 129µs to 26ms and is set by monitoring the voltage at TP1. However, this voltage is not linearly proportional to the dwell period, to allow finer resolution for shorter dwell periods. The relationship between the two is shown in a graph to be published next month.

By contrast, the debounce period can be set anywhere from 0-5ms. This is done by monitoring the voltage at TP2, with 1V on AN2 equivalent to 1ms (ie, the relationship is linear).

Links LK1-LK3 are used to select the various operational modes (see Table on Fig.3). These links connect to the RB5, RB6 & RB2 inputs (pins 11, 12 & 8) respectively. Internal pull-up resistors are enabled by IC1 so these inputs are held high with no jumper fitted. If a link is fitted, its corresponding input is pulled to 0V.

The default setting is with all jumpers out, for normal operation. The invert link (LK3) is fitted if the trigger sense needs inverting, while LK1 is fitted to enable the "follow" mode (this mode is used with very noisy points, as explained earlier).

The spark test mode, selected when LK2 is fitted, causes the unit to charge and fire the coil at a rapid rate, regardless of the state of the trigger input. This allows a coil (or the module itself) to be tested without installing the unit in a vehicle. In this mode, trimpot VR1 is set to a fully anti-clockwise setting and then wound clockwise to give the best visual spark. VR2 can be used to set the spark rate, with a range



All the parts for the High-Energy Ignition Module go on a single PCB which fits inside a small metal diecast case (reluctor pick-up version shown). The full constructional and installation details will be in Pt.2 next month.

Parts List: High-Energy Ignition

1 PCB, code 05110121, 89 x 53mm
1 diecast aluminium case, 111 x 60 x 30mm (Jaycar HB5062)
2 cable glands to suit 3-6mm cable
1 transistor insulating bush
2 TO-220 3kV silicone insulating washers (Jaycar, Altronics)
1 4MHz HC-49 crystal (X1)
1 18-pin DIL IC socket
3 2-way pin headers, 2.54mm pitch
3 shorting links for headers
1 solder lug
1 crimp eyelet
4 6.3mm tapped Nylon standoffs
8 M3 x 5mm screws
3 M3 x 10mm screws
3 M3 nuts
2 M3 star washers
9 PC stakes
1 2m length of red automotive wire
1 2m length of black automotive wire
1 2m length of green automotive wire
1 2m length of white automotive wire

Semiconductors
1 PIC16F88-E/P microcontroller programmed with 0511012A.hex (IC1)
1 ISL9V5036P3 ignition IGBT (Q1) (X-On; x-on.com.au)
1 LM2940CT-5 low drop out 5V regulator (REG1) (Altronics Z0592, Jaycar ZV1560)

Capacitors
1 100µF 16V PC electrolytic
1 10µF 16V PC electrolytic
1 470nF MKT
3 100nF MKT
1 1nF MKT
2 22pF ceramic

Resistors (0.25W 1%)
1 100kΩ 2 2.2kΩ
1 47kΩ 2 1kΩ
2 10kΩ mini horizontal trimpots (VR1,VR2)

Miscellaneous
Angle brackets for mounting, automotive connectors, self-tapping screws, heatshrink tubing, etc

Points version
1 100Ω 5W resistor (R1)

Reluctor version
1 BC337 NPN transistor (Q2)
1 2.2nF MKT capacitor
1 470pF ceramic capacitor
1 100kΩ top adjust multi-turn trimpot (VR3)
1 47kΩ 0.25W 1% resistor
1 10kΩ 0.25W 1% resistor
1 10kΩ 0.25W 1% resistor (R4)
1 1kΩ 0.25W 1% resistor (R3)
2 PC stakes

Hall Effect/Lumenition Module
1 1kΩ 0.25W 1% resistor (R3)
1 100Ω 0.25W 1% resistor (R2)
2 PC stakes

Optical Pick-up
1 optical pick-up (Piranha or Crane)
1 22kΩ 0.25W 1% resistor (R3 or R6)
1 120Ω 0.25W 1% resistor (R4 or R5)
2 PC stakes

of 15-75Hz (clockwise for increased frequency).

Bits & pieces

IC1 operates with a 4MHz crystal to ensure accurate debounce and dwell settings, regardless of temperature. We recommend using the extended version of IC1 (ie, the PIC16F88-E/P) which will operate reliably up to 125°C, compared to 85°C for the industrial version (PIC16F88-I/P).

IC1 is powered from a regulated 5V supply. This is derived using REG1, an LM2940CT-5 low-dropout regulator designed specifically for automotive use. It features both transient overvoltage and input polarity protection and it provides a regulated 5V output even if its input voltage drops as low as 5.5V, eg, when starting the engine in cold weather with a partially flat battery.

REG1 has a 470nF bypass capacitor at its input and a 100µF filter capacitor at its output, both of which are required for stable operation. The input capacitor is non-polarised so that it will not be damaged if the supply polarity is inadvertently reversed.

Trigger input options

Fig.4 shows the various trigger input

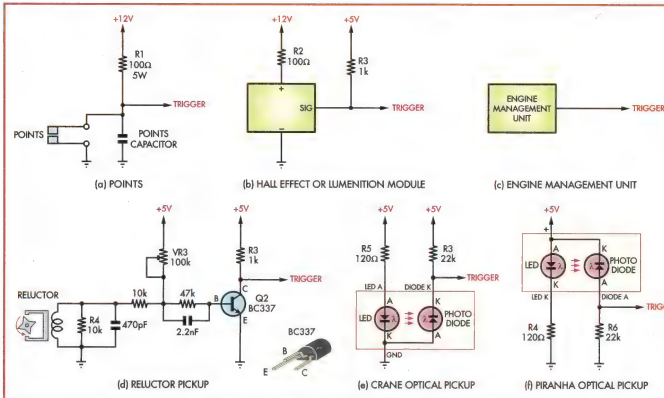


Fig.4: the six input trigger circuits: (a) points triggering; (b) Hall effect (and Lumenition) triggering; (c) triggering from an engine management module; (d) reluctor pickup; (e) Crane optical pickup; and (f) Piranha optical pickup. These different trigger options are all catered for on the PCB and it's simply a matter of installing the relevant parts.

circuit options. We'll look at each of these in turn:

- **Points:** Fig.4(a) shows the points input circuit. This simply comprises a 100Ω 5W resistor (R1) which connects between the top of the points and the 12V supply (the points capacitor is already present in the vehicle). This 100Ω resistor acts as a pull-up for the trigger input and it also provides a "wetting current" to ensure that the contacts remain clean.

The points are connected between the trigger input and ground. As a result, the trigger input is pulled low each time the points close and high (via the 100Ω resistor) each time they open.

- **Hall Effect:** Fig.4(b) is for a Hall effect or Lumenition (optical trigger) sensor module. This module is powered via a 100Ω resistor (R2) from the 12V rail, to limit the current into an internal clamping diode. A 1kΩ resistor (R3) on the output is also included, to pull up the output to 5V when the internal open collector transistor inside the sensor module is off. Conversely, the trigger output falls to nearly 0V when that transistor is on.
- **ECU:** the circuit for a vehicle with an engine management computer is shown in Fig.4(c). It's very simple – the 5V output signal from the computer simply connects to the trigger input of the ignition module.
- **Reluctor:** the reluctor input circuitry is shown in Fig.4(d). In operation, the output from the reluctor produces an AC signal, switching transistor Q2 on and off. Initially, with no reluctor output voltage, transistor Q2 is switched on via current through trimpot VR3 and the 47kΩ resistor to its base. The actual voltage applied to Q2's base depends on VR3, the two 10kΩ resistors (one across the reluctor coil) and the internal resistance of the reluctor itself.

Trimpot VR3 allows the circuit to be adjusted to suit a wide range of reluctor resistance values. In practice, VR3 is adjusted so that Q2 is just switched on when there is no signal from the reluctor. When the reluctor signal goes positive, Q2 remains switched on. Conversely, when the signal swings negative, Q2 switches off.

The signal output is taken from Q2's collector and this provides the trigger signal for the ignition module.

Resistor R4 provides the necessary load for the reluctor, while the parallel 470pF capacitor shunts very high frequency signals to ground. The 2.2nF capacitor across the 47kΩ base resistor speeds up Q2's switch-on and switch-off times.

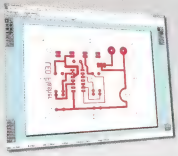
- **Optical:** finally, Figs.4(e) & 4(f) respectively show the Crane and Piranha optical trigger pick-up circuits. The Crane trigger has a common-ground connection while the Piranha has a common positive but apart from that, they operate in similar fashion.

For the Crane trigger, resistor R5 limits its internal LED current from the 5V supply while R3 pulls up the photodiode output. Similarly, for the Piranha system, R4 is the LED current-limiting resistor, while R6 pulls down the photodiode output.

All the different trigger options shown on Fig.4 are catered for on the ignition module's PCB. It's just a matter of installing the relevant parts (more on this next month).

What's coming

That's it for now. Next month, we will go through the construction, set-up and installation of the High-Energy Electronic Ignition System. **SC**



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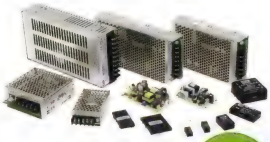

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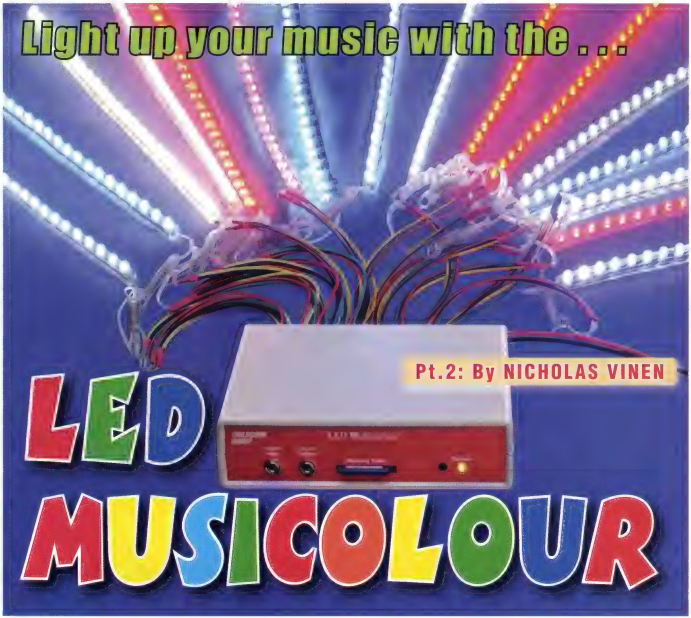


The new LED Musicolour makes building a spectacular light and music show easier than ever. In this second and final instalment, we explain how to build and test the unit and also detail how you can control it.

WE'LL GET onto the construction of the LED Musicolour shortly. Before we do, let's quickly look at a few more design details.

One aspect of the unit's operation that we didn't mention in Pt.1 is the automatic gain control (AGC). This applies when you are feeding audio into the unit via the audio line input socket (CON11). The problem is that line level signal amplitude can be quite variable and we don't want the lights to be driven dimly simply because your signal source has a low peak voltage.

To solve this, we constantly monitor the peak voltage at the audio inputs and apply an asymmetrical low-pass (smoothing) function to it. The output of this function remains close to the long-term peak of the audio signal, even though the amplitude won't be constant. We do this by allowing the detected peak voltage value to increase rapidly but only decrease slowly.

Given this detected peak amplitude, we can then "normalise" the audio data by computing a gain value which is the inverse of this peak amplitude, ie, the lower the amplitude, the higher the gain. This gain is applied before the Fast Fourier Transform (FFT) function is applied to the audio data. The output of the FFT then gives a consistent brightness level over a range of input signal amplitudes from around 500mV RMS up to a little over 2V RMS.

When we describe the configuration options later, you will see that there are a few options which control the rate at which the AGC level changes and the maximum gain setting available. We've chosen defaults that work well

in most circumstances so you won't normally need to change these.

Memory cards

Throughout these articles we have generally referred to the memory card as an "SD card". There are actually several different types of SD card. These days, most cards sold are actually SDHC (high capacity) cards in the range of about 4GB-32GB. We have successfully tested the largest of these cards in the LED Musicolour.

It should also support the older MMC cards although they are basically obsolete now. We haven't tested SDXC (64GB+) cards but in theory, they should work too as they still support the 1-wire SPI interface we are using to communicate with the memory card.

Construction

Building the main PCB is relatively straightforward and should take just a few hours. Fig.3 shows the parts layout. The board is coded 16110121 and measures 103 x 118mm.

The 11 SMD components are mounted first, ie, the eight dual Mosfets (Q1-Q8), audio DAC IC2, the 10µF ceramic capacitor for IC1 and the SD card socket (CON13).

Start with Mosfets Q1-Q8, which are in 8-pin SOIC packages. In each case, the pin 1 dot goes towards the lefthand side of the PCB. Place a small amount of solder on one pad, line up the IC and slide it into place while heating that solder. If it isn't positioned correctly on its pads, reheat the solder and reposition it. Make sure it's sitting flat on the board, then solder the remaining pins. Finally, add some more solder to the first pin.

That done, check that there are no bridges between the pins. If there are, use solder wick to clean them up. That's best done by first adding a little liquid flux paste (no-clean type) along both rows of pins and then removing any excess solder using the solder wick. You can clean up the flux residue with isopropyl alcohol if you like.

Note that for each of Q1-Q8, two pairs of pins share a single, larger pad. These are the two Mosfet drains. Obviously you don't have to worry about these being bridged although you should check that the two drains are not accidentally shorted.

Fit the rest of the SMD parts using the same method, with the exception

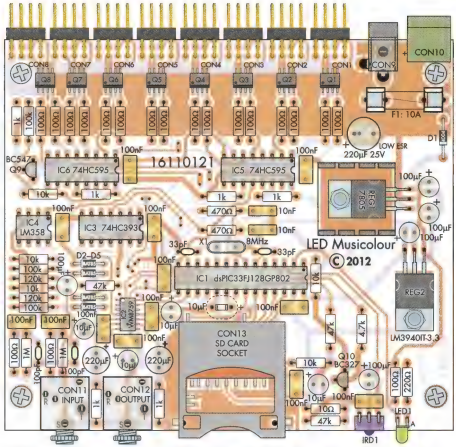


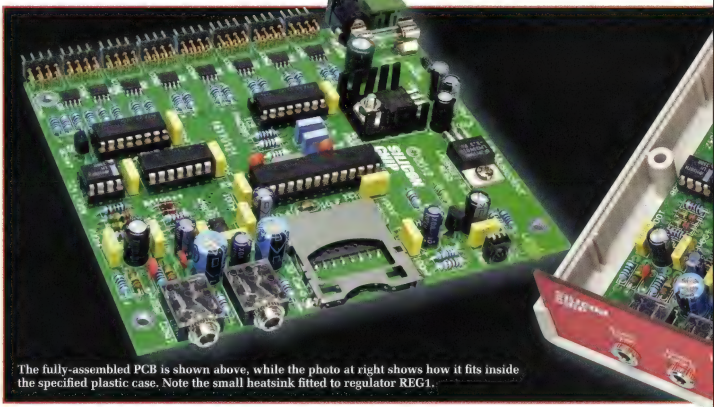
Fig.3: install the parts on the PCB as shown in this diagram, starting with the SMD components. The off-board LED strips are connected to pin headers CON1-CON8 via matching header sockets. Note that infrared receiver IRD1 is installed upside down (see text and photo).

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104
10nF	0.01µF	10n	103
100pF	NA	100p	101
33pF	NA	33p	33

Table 1: Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
2	1MΩ	brown black green brown	brown black black yellow brown
2	120kΩ	brown red yellow brown	brown red black orange brown
3	100kΩ	brown black yellow brown	brown black black orange brown
3	47kΩ	yellow violet orange brown	yellow violet black red brown
5	10kΩ	brown black orange brown	brown black black red brown
1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
6	1kΩ	brown black red brown	brown black black brown brown
2	470Ω	yellow violet brown brown	yellow violet black black brown
1	220Ω	red red brown brown	red red black black brown
19	100Ω	brown black brown brown	brown black black black brown
1	10Ω	brown black black brown	brown black black gold brown



The fully-assembled PCB is shown above, while the photo at right shows how it fits inside the specified plastic case. Note the small heatsink fitted to regulator REG1.

These two photos show the mounting details for the infrared receiver (IRD1). It must be mounted upside down (so that its lens lines up with the adjacent LED), with its leads run down the back of its body.

of the SD card holder. This has two plastic posts which go into holes on the PCB, holding it in position. You then solder the larger mounting tabs, followed by the signal pins. There are 15 in all; remove and discard the plastic insert before soldering those inside the socket.

Through-hole parts

Now mount the resistors, checking each value with a DMM first. You can refer to the colour code table but the multimeter is more reliable. Follow with diode D1 (1N4004) and then the four smaller Schottky diodes, D2-D5. In each case, ensure that the cathode stripe is orientated as shown.

Solder crystal X1 in place next, then fit the IC sockets or, if you are not using a socket at any location, the IC itself. It's a good idea to use a socket for IC1 but the rest are optional. Either way, make sure the pin 1 notches are all orientated towards the righthand side of the PCB, as shown on the overlay.

Next, bend REG2's leads down through 90° about 7mm from its tab, then use an M3 x 6mm machine screw, shakeproof washer and nut to fasten it to the board. Do the screw up tight, then solder and trim the leads.

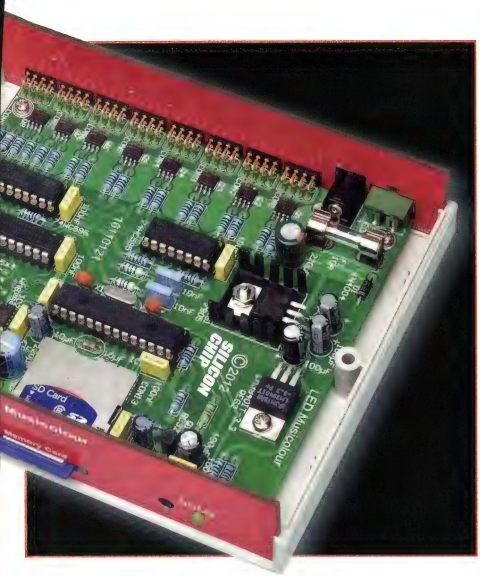
That done, install the two 3.5mm stereo jack sockets. These must sit flush against the PCB and must be correctly aligned with its edge. Follow with the two small signal transistors, taking care not to get them mixed up. Bend their leads with small pliers to suit the pad spacing on the board.

Pin headers CON1-CON8 can now go in. If you can't get 8-pin dual row right-angle pin headers, make them from longer, snappable headers. Do this carefully using pliers and file off any burrs. Check that each header fits through the hole in the rear panel before soldering it to the PCB. When doing so, take care that the projecting pins are parallel to the surface of the PCB and at right-angles to the edge.

If one of the headers won't fit through the rear panel, a few strokes with a needle file will generally take off enough plastic to fix it. This is easier to do before the header is soldered to the board. It's also a good idea to check the alignment of each header once you have soldered a couple of its pins.

With the pin headers in place, you can then mount CON9 and CON10, again checking that they are aligned correctly to fit through the rear panel hole. Follow with the two fuse clips; push them down all the way onto the PCB and check that the end-stops are on the outside.

The MKT and ceramic capacitors go in next, in the locations shown on the overlay diagram. Follow with the



electrolytic capacitors, ensuring that in each case, the longer lead goes into the hole marked with a "+" on the overlay diagram.

That done, bend the green LED's leads down 2mm from its lens so that when fitted, its anode (longer lead) will go towards the right. Solder it in place with the horizontal portion of the leads 3mm above the PCB. Don't trim the leads too short in case you need to adjust it later.

Infrared receiver

IRD1 is installed in an unusual manner – basically upside-down, so that the centre of its lens is aligned with the other front panel connectors and the LED. This means the leads run down the back of the receiver and the top of the housing sits on the surface of the PCB.

We used a plastic-encapsulated type but some infrared receivers have a metal shield. **Because the leads run near the body of the device and because of the exposed pads on the PCB, you will have to place an insulating layer (eg, electrical tape) over the back and top side of the receiver.**

There's a bit of a trap here because you might expect that this is unnecessary for IR receivers which have a plastic case. In fact, many of these use a conductive type of plastic (for shielding) so you should put some insulation along the rear and top of these as well. Make sure the body can't make contact with the leads or PCB pads. If it does, the receiver won't work.

Once you're ready, bend the leads through 180°, against the insulation layer on the rear of the receiver, then push it down all the way onto the PCB and solder it in place. The accompanying photos show how we did it.

Now bend regulator REG1's leads down through 90° in a similar manner as for REG2. This device is then fastened to the PCB along with a mini-U heatsink using an M3 x 10mm machine screw nut and flat washer. Tighten the screw firmly before soldering and trimming REG1's leads.

The PCB assembly can now be completed by fitting the 10A fuse and plugging the ICs into their sockets. Make sure that the pin 1 notch or dot of each IC goes towards the righthand side of the PCB – see Fig.3.

Putting it in the case

Before fitting the PCB into the case, first you must cut off or file down the four inner plastic posts in the base, ie, the ones which don't correspond with the PCB corner mounting holes. That done, push the rear panel onto the PCB connectors until it sits against the edge of the board. It should be a tight fit.

If it won't go, carefully use a needle file to slightly enlarge the offending cut-out and try again.

With the rear panel in place, you can then unscrew the nuts for the two 3.5mm stereo sockets and slip the front panel on. It should fit easily but again, if it doesn't, a little filing should fix it. Check that LED1 and infrared receiver IRD1 are properly aligned with their holes and if not, adjust them. Once the panel is in place, refit the two nuts to the sockets to hold it in place.

You can now slip the whole assembly down into the channels in the bottom of the case and attach the board to the integral stand-offs using four self-tapping screws.

Testing

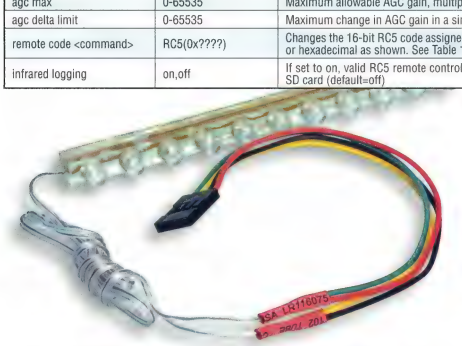
It's best to test the unit initially without the LED strips plugged in. You can use a 7.5-24V DC plugpack if you have one handy. Alternatively, use the 12-24V power supply you will be using later.

Plug in the supply and switch on. Check that LED1 lights immediately. If it doesn't, switch off and check for faults (make sure IC1 has been programmed correctly). If all is well, measure the outputs of REG1 and REG2. Connect the negative lead of a DMM to the tab of either regulator and then, with the board orientated as in Fig.3, measure the voltage on the top pin of REG1 and the lefthand pin of REG2. You should get readings in the range of 4.8-5.2V for REG1 and 3.2-3.4V for REG2.

If you plan to use an infrared remote control, you can point a universal remote set for a common Philips device code (TV, VCR, etc) and press some buttons. The green LED should flash

Table 3 – Configuration Commands

Setting	Valid Options	Description
mode	0-9	Which light display mode the unit starts up in (default=0)
spectrum attack	0-255	If set below 255, limits the rate at which LED brightness can increase (default=255)
spectrum decay	0-255	If set below 255, limits the rate at which LED brightness can decrease (default=255)
min brightness	0-255	Brightness level below which a strip remains off (default=8)
default playback order	sorted,shuffle,directory	Which order WAV files and folders are processed (default=sorted)
default volume	0-100%	The initial sound output volume (default=100%)
start playback automatically	yes,no,true,false	If yes/true, playback starts immediately
default repeat all	yes,no,true,false	If yes/true, when the last file is finished playing, it starts again with the first (default=yes)
agc filter coefficient	0-65535	AGC low-pass filter coefficient, lower values give slower gain changes (default=16)
agc max error	0-65535	Amount by which AGC output is allowed to deviate from nominal before gain changes (default=256)
agc max	0-65535	Maximum allowable AGC gain, multiplied by 4096 (default=16384, ie, gain of four)
agc delta limit	0-65535	Maximum change in AGC gain in a single step (default=4)
remote code <command>	RC5(0x????)	Changes the 16-bit RC5 code assigned to a given command; number can be decimal or hexadecimal as shown. See Table 1 for command names.
infrared logging	on,off	If set to on, valid RC5 remote control codes detected are written to a log file on the SD card (default=off)



This view shows how the LED strips are wired to the 4-way header sockets. The two outer leads go to the positive rail while the inner leads go to the negative rail, so the socket can be plugged into a header either way around.

Modes 2-9 are similar to modes 0 and 1 but are intended for use when you have more than one LED Musicolour unit. For two units, you feed them the same audio and then use either modes 2 & 3, with each unit processing half the frequency bands, or modes 4 & 5, with each unit processing one channel. With four units, set them to modes 6-9.

Of course, if you prefer the way one of these other modes looks with a single Musicolour, there's nothing stopping you from using it that way too.

Configuration file

So that you don't have to change the settings with the remote control each time you power the unit on, you can record them in a configuration file in the root folder of the SD card. This works even if you don't want to use the SD card to play back audio; if you don't put any WAV files on the card, the unit will instead utilise its audio input, just as if there was no card inserted.

This file must be called "LED Musicolour.cfg" and contains one line per setting. Each line starts with the name of that setting, then has an equals sign ("=") and then the value. The options are shown in Table 3. Any settings not specified remain at the default value.

There are some options to control parameters that you can only set using the configuration file. For example, if you want to simulate a "peak hold" spectrum analyser, you can set the spectrum decay setting low (say, to 8). This means that a LED strip driven at full brightness will stay on for 256 ÷ 8 = 32 window periods or about 1.5 seconds. You can play around with the attack and decay settings to see if you prefer the effect achieved.

As you can see from the table, there are quite a few settings although many of them are provided for people who really want to tweak the way the unit works. Most of the settings can simply be left at their defaults.

SD card bootloader

In case of bugs in the firmware, we have incorporated a "bootloader". This checks for the presence of a certain HEX file in the root folder of the SD card when power is first applied. If it exists and its contents differ from the micro's flash memory, the bootloader re-flashes the micro.

During this process, LED1 flashes. From then on, the microcontroller will run using the new firmware from that HEX file.

The file must be called "LED Musicolour.hex". If we release an updated version of the firmware, it will probably have a different file name so you will need to rename it after copying it to the memory card. Once the unit has successfully been re-flashed, you should delete the file from the SD card.

That's it; enjoy the show! SC

Jaycar Electronics

Better, More Technical

HAPPY BIRTHDAY

NOVEMBER EDITION

Prices valid until 23/11/2012

200WRMS 12" Party Speaker

This speaker can handle a massive 200WRMS and an excellent addition to any entertainment equipment range. It provides good performance in difficult locations such as backyards, tents, party rooms or halls etc.

- 1 x 12" woofer
- 1 x wide dispersion piezo horn
- Size: 620(H) x 400(W) x 330(D)mm

CS-2514

BUY 2 for $350 SAVE $48

$199.00

200WRMS Stereo Amplifier

2 x 200WRMS per channel stereo amplifier with remote control.

- Remote control included
- Distortion: <0.003%
- Inputs: DVD/CD, Aux 1&2, Phono, Tap, USB
- Size: 430(W) x 241(D) x 114H)mm

AA-0484 *was $329.00*

$279.00 SAVE $50

Rotating Disco Ball with LED Spotlights

Features an automatic rotating mirror ball, two adjustable angle spotlights each with 6 red, green and blue LEDs. An additional 4 red and blue LEDs are on the base for maximum effect. Mains power adaptor included.

- Size: 260(L) x 130(W) x 230(H)mm

SL-2916

$39.95

PC Programmable Line Tracer Kit

Learn about robotics and programming with this line tracer kit. Run it in line tracer mode by drawing a thick dark line on paper for the robot to follow.

- Suitable for ages 12+
- Requires 2 x AA batteries
- Size: 120(L) x 64(W) x 55(H)mm

KJ-8906

NEW $34.95

BIRTHDAY BONUS

Ask for your **FREE** *Jaycar Cooler Bag when you spend $50 or more from our Birthday flyer*

Motion Tracking Spotlight

A unique way to protect your home against intruders. Motion is detected via the two front facing PIR sensors. Once activated, the light will pan left or right to follow a person. Mains plugpack included.

Lights follow you

- 4 x 3W LEDs, 500 lumens
- Up to 13m detection range
- Built-in dummy camera with blinking LED
- Size: 220(L) x 76(D)mm

SL-2705

NEW $149.00

Rotates 240˚

Universal Wi-Fi Extender

Eliminate Wi-Fi dead zones and extend the range of existing 802.11b/g/n networks with ease. Just plug the unit into an existing power point in your home and within seconds it will help detect available Wi-Fi networks and establish connection using the easy iQ setup. See website for specifications.

- Size: 76(H) x 47(W) x 41(L)mm

YN-8360

NEW $69.95

iPhone® Controlled RC Helicopter

Control from your iPhone®/iTouch®/iPad® or Android™ Smartphone using free app available on iTunes®.

- 3 Channel, IR transmitter
- Gyroscope for stable flight
- 25 min charge for 5 min flight time
- Includes USB charger
- Suitable for ages 14+
- Size: 135mm long

GT-3460 *was $79.95*

$49.95 SAVE $30

iPhone® not included

Snow Machine

The jet of snow consists of small dense foam balls which float to the ground like real snow to create an artificial blanket on the ground. Once it lands the snow slowly dissipates leaving a light residue. Includes mounting bracket and wireless remote control. See demo video on our website.

- 240VAC operation
- 1.3 Litre fluid capacity
- Size: 337(L) x 260(W) x 227(H)mm

AF-1216

$99.00

Snow juice sold separately:

1L (**AF-1217** $9.95)

2L (**AF-1219** $14.95)

3L (**AF-1218** $19.95)

FREE 2L Snow Juice (AF-1219) VALUED AT $14.95

17" Colour LCD Monitor

ASUS

High resolution slimline monitor suitable for surveillance applications. Its 4:3 aspect ratio means the camera vision won't appear distorted or stretched, unlike 16:9 monitors.

- Inputs: DVI, VGA and Audio
- Speakers: 2 x 1W stereo
- Size: 378(W) x 315(H) x 62(D)mm

QM-3577

NEW $199.00

2 Ch MIDI DJ Mixer

Mix, play and scratch your own MP3 tracks directly from your PC. The mixer sends MIDI data from the controller to your DJ software without the inconvenience of mouse control. It's a fully class-compliant USB MIDI device complete with Virtual DJ software. See website for full features and specs

- 2-deck controller
- Mix 2 files in 1 controller
- USB powered
- Size: 358(W) x 260(H) x 45(D)mm

AM-4252 *was $249.00*

$199.00 SAVE $50

PARTY AT JAYCAR

2 Way Ceiling Speakers

Combining a coaxial woofer and dome tweeter these 2 way ceiling speakers give excellent audio quality compared to traditional PA speakers. With a flush mount design and fold out retaining clamps they are easy to install in new or existing ceilings. They are an excellent addition to entertaining spaces, home theatres, or office spaces.

- 8 ohm impedance
- White grille included

Sold as a pair

Available in 3 sizes:

5.25" 25WRMS CS-2451 $59.95
6.5" 30WRMS CS-2453 $79.95
8" 40WRMS CS-2455 $99.00

NEW FROM $59.95

2 Way Enclosed Can Ceiling Speaker

A 2-way ceiling mount speaker with sealed housing to improve low frequency response and protect the speaker from dust, debris, and insects. Featuring a 6.5" woofer and silk dome tweeter it can be flush mounted or suspended in mid air using chain or cable with a white clip on cover to conceal the speaker and mounting screws.

- Sold individually
- 30WRMS @ 8 ohm
- Size: 232(Dia.) x 190(L)mm

CS-2462

NEW $69.95 ea

JV60 DIY Speaker Kit

The JV60 speaker kit offers a level of sound quality that punches well above their price weight compared to many imported European speakers. By investing a couple of hours of your own time to build this superb system to compliment most mid-powered amplifier/receivers, you can save hundreds over commercial equivalents. Speaker Kit sold in two parts; speaker components with mounting accessories and pre-built speaker cabinets.

Place your order in-store and we'll build it for you!

- Power Handling: 150WRMS

JV60 Speaker Kit with Crossovers & Accessories - Pair

- Speaker kit includes woofers, tweeters, crossovers and mounting accessories
- 4 x 6.5" VIFA P17WJ (see CW-2106 for specs)
- 2 x VIFA D35AG (see CT-2020 for specs)
- 2 x 3-way, Linkwitz-Riley crossover

CS-2560 ***was $499.00***

$449.00 SAVE $50

JV60 Prebuilt Cabinets - Pair

- Bass reflex design with corner frequency of 35Hz
- Pre-built with all holes cut out for components
- Finished in "blackwood" veneer
- 1090(H) x 250(W) x 260(D)mm (50L internal volume)

CS-2562 ***was $199.00***

$149.00 SAVE $50

Pre-assembled JV60 Complete - Pair

We are also offering a fully assembled version if you just don't have the time but still want to experience the quality performance of this design.

CS-2564 ***was $899.00***

$799.00 SAVE $100

Hi-Fi Stereo Bluetooth® Headset

Listen to MP3 music from a mobile phone or a PC without any cables. Features a full cup leatherette headset and rechargeable Li-Po battery. Perfect for the commuter, student, or multi-tasker.

- Allows 2 devices to be connected simultaneously
- Supports A2DP, AVRCP, headset, hands free profile
- Low battery LED and audio indication
- Working range: up to 10m

AA-2082

$69.95

2 Ch UHF Wireless Microphone

Offers superior performance and convenience found on more expensive models. Incorporates easy to use infrared pairing for microphones, wireless transmission can reach up to 100m line of sight.

- 2 microphones included
- Requires 4 x AA batteries
- Size: 420(W) x 210(D) x 45(H)mm

AM-4122

$249.00

Also available additional microphones to suit:

Handheld Mic Ch A	AM-4123	$119.00
Handheld Mic Ch B	AM-4126	$119.00
Lapel Mic Ch A	AM-4065	$99.00
Lapel Mic Ch B	AM-4066	$99.00

10 Way Headphone Listening Centre with Microphone

Distributes audio signal across up to 10 headphones and has a built-in amplifier which prevents loss of sound quality. Each channel has its own volume control. Supplied with a mains power adaptor, 1 x dynamic microphone and 1 x 2 metre 3.5mm plug to 6.5mm plug stereo lead.

- Output power: 220mW (32ohm)
- Headphone impedance: 16-64ohm
- Size: 191(W) x 95(H) x 45(D)mm

AA-0403 ***was $149.00***

$129.00 SAVE $20

Belt Pack Portable PAs

Stylish and portable PA speakers designed to be worn around the waist. Perfect for outdoors activities, lectures and presentations etc.

AM-4060

Both units include:

- Wired headset microphone
- Rechargeable battery with mains charger
- Adjustable belt
- Aux audio input

FROM $69.00

3.5" Speaker AM-4060 $69.00
4" Speaker with MP3 Player AM-4062 $89.00

Portable Wireless PA Amplifier & Microphone

Consists of a compact yet powerful amplifier with a built-in crystal locked radio receiver and wireless microphone. The mic. is attached to a small ear-hook gooseneck that allows 'hands free' operation.

- 20WRMS output
- 6" speaker
- Size: 260(H) x 182(W) x 125(D)mm

AM-4075

$99.00

2 x 15WRMS Portable Stereo Amplifier

Runs off 8 x AA batteries (not included) or by the included AC adaptor. It outputs 15WRMS per channel using a digital signal processor and features spring-loaded push terminals and a 1.8m coiled 3.5mm male-to-male cable for connection to a PC, iPod®, MP3 player or portable CD player.

- Power: 2 x 15WRMS
- Output impedance: 4 ohm
- Size: 150(W) x 130(D) x 30(H)mm

AA-0487

$49.95

2 x 50WRMS Compact Stereo PA Amplifier

Uses digital sound processing to deliver the quality of a Class AB amplifier with the efficiency of a Class D. Features solid aluminium body, high current rated banana socket speaker terminals, stereo RCA audio input, front panel mounted 3.5mm stereo input and a 6.5mm headphone socket means it also doubles as a headphone amplifier.

- Power: 2 x 50WRMS
- Output impedance: 6 ohm
- Size: 78(W) x 150(D) x 50(H) mm

AA-0488

$149.00

Keypad Shed Alarm

Simple and effective garage or shed alarm. Consists of a keypad, single reed switch for a door or window and 5m of cable for easy DIY installation. Use as an instant alarm, with an entry delay or as a door chime to announce entry. Requires a single 9V battery.

- Size: 162(H) x 85(W) x 32(D)mm

LA-5214

$19.95

BUY Shed Alarm & Get 2 x Large Alarm Sticker (LA-5102) FREE valued at $5.90

Economy 4 Channel DVR - D1 Resolution

Features 4 channel multiplexer, Ethernet functions, and H.264 video compression. It delivers D1 resolution video (704 x 576) at 100 frames per second. Playback can be displayed locally through the composite or VGA outputs and remotely via a network connection using a web browser or an iPhone®, iPad®, or Smartphone app*. Supplied with a 500GB HDD fitted, software and manual on CD, power supply, and quick start guide.

See website for full specifications.

- Built-in web server for network access
- Power supply included
- Size: 375(W) x 285(D) x 45(H)mm

QV-8120

500GB HDD included

Also available: 16-Channel D1 Resolution DVR QV-8122 $899.00

NOTE: *Remote access app available for iOS®, Android™, Blackberry®, Symbian®, and Windows Mobile® operating systems. See our website for more information.

$399.00

Biometric Finger Scan Safe

Provides secure storage using a finger print scan for fast and simple access in as little as 2 seconds! Features a built-in flash memory and ideal for storing money, passports etc. Mounting hardware included.

- Low battery warning
- Requires 4 x AA Alkaline batteries
- Size: 273(L) x 190(W) x 51(H)mm

HB-5457 *was $149.00*

$129.00 SAVE $20

iPhone® not included

Motion Activated Alarm with Remote Control

Avoid messy wiring and protect your belongings with ease using our battery operated, motion activated alarm. Remote control and mounting bracket included.

NEW $24.95

- Easy to install mounting bracket
- Alarm requires 3 x AA batteries
- PIR Sensor size: 114(L) x 61(W) x 29.5(D)mm
- Remote size: 64(L) x 32(W) x 7(D)mm

LA-5217

Pressure Activated Mat Alarm with Siren and Strobe

Simply slide the pressure sensitive pad under your door mat to be notified of guests when they arrive. Easy to install and maintain!

- Super loud 120dB+ siren
- Red strobe light
- Requires 1 x 9V alkaline battery
- Size: 490(L) x 330(W) x 3(D)mm

LA-5218

NEW $29.95

2 Station Wired Intercom

A simple low cost solution for communicating out to garage or keeping tabs on a sleeping baby. Battery powered & supplied with 20m connecting cable.

- Requires 9V battery or 9V plugpack

AM-4310 *was $24.95*

NOTE: Domestic use only. Warranty does not apply if product is used industrially.

$19.95 SAVE $5

Fingerprint Access Controller

The fingerprint scanner reads in less than two seconds! Enables you to enrol up to 120 users. It has a robust cast housing and all operating parameters are stored in a flash memory.

- All metal construction
- Weatherproof and tamperproof
- IR remote control
- Power supply: 12VDC
- Size: 68(W) x 115(H) x 32(D)mm

LA-5122 *was $149.00*

$129.00 SAVE $20

IP66 Infrared Door Beam Entry

Detects when a person or object crosses a boundary or entrance way. Features a weatherproof (IP66) casing and uses a modulated beam to resist interference from sunlight.

- Input voltage: 12 to 250V AC or DC
- Up to 15m range
- Sensor module size: 122(H) x 62(D) x 61(W)mm
- Reflector size: 82(Dia.)mm

LA-5179

NEW $99.00

Optional Accessories:

Door Beam Extension Buzzer

LA-5188 $34.95

Door Beam Counter Module LA-5197 $34.95

Digital Wireless Surveillance Camera Kits

Wireless camera and receiver packs provide simple and effective surveillance for the home or office. Using 2.4GHz DIGITAL technology to minimize interference and maximize range these camera and receiver packs give excellent performance. Available with a LCD screen receiver for viewing video on the go or with standard receiver for connection to an existing TV screen, both versions can also record video by adding an SD card (not included).

QC-3670

Receiver Features:

- Quad camera or single camera view
- Supports up to 4 cameras
- Accepts SD cards up to 32GB (sold separately)
- AV output for connection to separate monitor

Camera Features:

- Transmission range up to 100m line of sight
- 380TV Lines
- CMOS Image sensor
- Night vision distance up to 5m
- Weatherproof IP66 housing
- Size: 130(L) x 65(Dia)mm

NEW FROM $249.00

Camera with Standard Receiver

- Size:113(L) x 113(W) x 20(H)mm

QC-3672 $249.00

QC-3672

Camera with LCD Receiver

- 7" LCD screen
- Size: 190(W) x 113(H) x 20(D)mm

QC-3670 $349.00

Additional cameras available separately NEW

QC-3674 $149.00

DIY IP Cameras

Designed for use with any common household router. Access through web browser or iPhone®/Android™ app to see what is really going on while you're away. Features Wi-Fi and wired connectivity with easy setup and configuration options, and motion alarm detection which can email or FTP upload camera snapshots at a specified internal.

- MJPEG video compression • 1/5" Colour CMOS Sensor, 300k Pixels • Wireless transmission up to 50m

Wi-Fi Camera with IR LEDs

Our entry level DIY IP camera.

- Size: 140(H) X 105(W) X 95(D)mm

QC-3832

$89.00

Pan/Tilt Camera with IR

Pan/tilt functionality so you can change the view angle as you please.

- Size: 125(H) x 100(W) x 95(L)mm

QC-3834

NEW $119.00

Outdoor Wired/Wi-Fi Camera

Designed for external use with tough aluminium housing.

- Size: 95(L) x 85(H) x 30(W)mm

QC-3836

NEW $149.00

To order call 1800 022 888

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/11/2012.

TOOLS & COMPONENTS

75mm (3") Sheet Metal Bending Pliers

Bend sheet metal easily with this heavy duty offset hand tool. Features strengthened rivets and dual layered pitted handle for a firm grip.

- Jaw width: 75mm, Jaw depth: 30mm
- Overall length: 210mm

TH-2336

NEW $24.95

Inspection Camera with 2.4" LCD

See into extremely confined spaces including in wall cavities, behind heavy appliances, engine wells, etc. Features a CMOS sensor and two high-brightness LEDs for seeing into dark areas.

- 2.4" colour LCD
- 1m flexible gooseneck
- Requires 4 x AA batteries
- Size: 180(L) x 85(W) x 25(H)mm

QC-8714

NEW $99.00

240V Mains LED Light Globes

A range of mains LED light globes that are a true replacement for traditional lighting. Offers a brilliant lumen performance with wide, evenly spread light output across a 270° output angle, making them better than traditional light globes in many cases.

NEW FROM $14.95

SL-2214

Watts	Lumens	Colour	Base	Cat.	
5W	300	Warm white	Bayonet	SL-2210	$14.95
5W	300	Warm white	Screw	SL-2211	$14.95
5W	360	Natural white	Bayonet	SL-2212	$14.95
5W	360	Natural white	Screw	SL-2213	$14.95
10W	820	Warm white	Bayonet	SL-2214	$29.95
10W	820	Warm white	Screw	SL-2215	$29.95
10W	900	Natural white	Bayonet	SL-2216	$29.95
10W	900	Natural white	Screw	SL-2217	$29.95

7 Piece Screwdriver Set

High quality, bright red drivers you can find easily. Insulated right to the tip and rated to 1000V.

- Includes storage box

TD-2022

$19.95

BUY 2 FOR $30 Save $9.90

Self Crimping Solar Power Connectors

Designed for use with solar systems and feature a unique spring cage connection which attaches to your stripped cable without requiring a specialty crimping tool. See video on website.

- Silver plated copper contacts
- Current rating: 40A
- Voltage rating: 1100V

NEW $9.95 PO

IP67 Spring Cage Solar PV Socket PS-5120 $9.95

IP67 Spring Cage Solar PV Plug PP-5122 $9.95

3 in 1 Stud Detector with LCD Screen

Survey your wall with ease by sliding this handheld detector along the surface. With three modes to sense studs, cables, and metal this handy device allows you to locate and mark items hidden within a wall.

- Requires 9V battery
- Size: 150(H) x 67(W) x 28(D)mm

QP-2283

NEW $24.95

Digital Tyre Pressure Gauge

Keep track of tyre pressure and avoid pressure related problems. Measures pressure from 5 to 100PSI and includes an integrated torch for night time use.

$14.95 SAVE $5

- Includes 2 x AAA batteries
- Size: 156mm long

QP-2293 ***Was $19.95***

Arduino Experimenters Kit

Over $120 total retail value! SAVE $$$

Everything you need to get started for a fun range of electronics and Arduino related projects. Complete with instructions and a supporting web page and software examples.

- Includes Eleven Arduino compatible board
- No soldering required
- Size: 340(W) x 165(H) x 36(D)mm

XC-4262 DUE EARLY NOVEMBER

$89.95

Universal Battery Tester

This tester applies a load to the battery to get a measurement of the remaining capacity available for use, shown as a percentage on the LCD screen together with the battery voltage. Suitable for testing AA, AAA, C, and D, 9V batteries, 1.5 and 3V button cells and 6 & 12V cylindrical cells.

NEW $14.95

- Includes 2 x LR44 batteries
- Size: 128(L) x 45(W) x 20(D)mm

QP-2256

Mains Double Adaptor with 2 x USB Ports

Provides 2 x mains sockets and 2 x USB sockets for recharging all manner of tablets and Smartphones. Surge protected.

- USB socket output: 5V at 1A
- Size: 91(W) x 72(L) x 55(D)mm

PP-4037

NEW $17.95

USB Dataloggers

These USB dataloggers log temperature and humidity readings and store them in internal memory for later download to a PC.

Direct Plug in Type

- Easy USB interface
- 32,000 memory samples
- Size: 100(L) x 22(W) x 20(H)mm

QP-6013 ***was $119.00***

$99.00 SAVE $20

USB / LCD Readout Type

- Adjustable measurement cycle
- 32,700 memory samples
- Size: 95(H) x 50(W) x 32(D)mmm

QP-6014 ***was $179.00***

$149.00 SAVE $30

Compact Switchmode Laboratory Power Supplies

Compact size, high current, variable output and fan cooling make these the ideal power supply for your bench. They are protected against thermal overload and short circuit and will display a warning LED in the event of a fault condition. Current and voltage are displayed on separate backlit analogue meters.

- Size: 148(W) x 162(D) x 62(H)mm

0 - 24VDC 15A MP-3800
was $149.00 now $129.00 save $20.00

0 - 16VDC 25A MP-3802
was $199.00 now $179.00 save $20.00

FROM $129.00 SAVE $20

Snap On Battery Terminals

Used for protecting the exposed positive/negative battery connections from dust, grime or other build up. Ideal for automotive, marine, or industrial use.

- Rated at 500A
- Red and black supplied
- Size: 66(L) x 42(W) x 25(H)mm

HM-3087 Battery not included

NEW $14.95 pair

To order call 1800 022 888

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/11/12.

KITS – BUILD THEM!

Kits for Kids

The perfect gifts for the young scientist!

- Suitable for for ages 8+

Balloon Powered Helicopter Propulsion Kit

A simple little kit to demonstrate how helicopter flight is possible. Instructions included.

- 43 second assembly time
- Suitable for ages 5+
- Size: 260(Dia.) x 30(H)mm

KJ-8908

NEW $14.95

Principles of Electric Current Experiment Kit

Learn the common principles of electric current and magnetism.

- 30min assembly time
- Requires 2 x D batteries, scissors, and tape
- Suitable for ages 8+
- Size: 99(L) x 70(W) x 45(H)mm

KJ-8901

NEW $9.95

Mini Electric Experiment Motor Kit

Understand the technology of how an electric motor works. Includes all the main components to create a working DC motor.

SEE VIDEO ONLINE

- 30min assembly time
- Requires 3VDC-6VDC power source
- Suitable for ages 8+
- Size: 132(L) x 104(W) x 90(H)mm

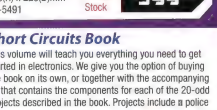
KJ-8902

NEW $19.95

DAB+/FM Digital Radio Kit

Refer: Silicon Chip Magazine June, July, August 2010

Many Hi-Fi enthusiasts want to add a digital tuner to their system and want great function and sound quality. This unit covers DAB+ and FM, has analogue and optical audio outputs, IR remote (included), an external antenna connector and is powered by mains plugpack. The kit is complete with everything, including the Hi-Fi component case. See website for full specifications.



- Case size: 445(L) x 75(H) x 225(D)mm

KC-5491

Hurry! Limited Stock

$399.00

Ultrasonic Antifouling Kit for Boats

Refer: Silicon Chip Magazine September/October 2010

Marine growth electronic antifouling systems can cost thousands. This project uses the same ultrasonic waveforms and virtually identical ultrasonic transducers mounted in a sturdy polyurethane housings. By building it yourself (which includes some potting) you save a fortune! The single transducer design of this kit is suitable for boats up to 10m (32ft); boats longer than about 14m will need two transducers and drivers. Basically all parts supplied in the project kit including wiring and epoxies.

YS-5600

KC-5498

- 12VDC, suitable for power or sail
- Could be powered by a solar panel/wind generator
- PCB size: 78 x 104mm

KC-5498

$249.00

Pre-built also available:

- ***Dual output*** Suitable for vessels upto 14m (45ft) YS-5600 $899.00
- ***Quad output*** Suitable for vessels upto 20m (65ft) YS-5602 $1199.00

Jacob's Ladder High Voltage Display Kit MK2

Refer: Silicon Chip Magazine April 2007

With this kit and the purchase of a 12V ignition coil (available from auto stores and parts recyclers), create an awesome rising ladder of noisy sparks that emits the distinct smell of ozone. This improved circuit is suited to modern high power ignition coils and will deliver a spectacular visual display. Kit includes PCB, pre-cut wire/ladder and electronic components.

- 12V car battery, 7Ah SLA or 5A DC power supply required
- PCB: 170 x 76mm

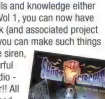
KC-5445

$42.95

Headlight Reminder Kit

Refer: Silicon Chip August 2001

Features include a modulated alarm, ignition and lights monitoring, optional door switch detection, time-out alarm and a short delay before the alarm sounds. Kit includes quality solder masked PCB with overlay, case with screen printed lid and all electronic components.



- 12VDC
- PCB: 78 x 49 mm

KC-5317

$27.95

Party Lighting Kits

Limited stock. Not available online

DMX Controller USB Interface

This kit controls DMX fixtures such as spotlights using a PC and USB interface. It can also be operated in stand-alone mode that outputs all 512 channels at the same time (9V battery required for stand-alone mode). Includes software, USB cable and enclosure.

- Test software and DMX Light Player software included
- 512 DMX channels
- 3 pin XLR-DMX output connector

KV-3610

CRAZY PRICE

$99.00

DMX Relay Control Kit

Control a relay with the DMX512 protocol. The relay will be activated when the DMX value of the set channel equals 140 or more and turns off when the value is 120 or less. Team it with KV-3610 to make a computer-controlled automation system. Short form kit.

- 512 unique addresses, DIP switch settable
- Relay hold function in case of DMX signal loss

KV-3612

CRAZY PRICE

$29.95

DMX Control Dimmer Kit

Allows you to control a lamp or group of lamps through a DMX signal. You can use the USB Controlled DMX Interface kit or any other control console compliant with the DMX-512 protocol as a controller. It will drive resistive loads like incandescent lamps and mains voltage halogen lighting. Shortform kit.

- 512 unique addresses, selectable with DIP switch
- Status LED for power & error detection
- Stand alone mode for testing

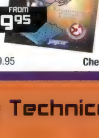
KV-3614

CRAZY PRICE

$49.95

Short Circuits Book

This volume will teach you everything you need to get started in electronics. We give you the option of buying the book on its own, or together with the accompanying kit that contains the components for each of the 20-odd projects described in the book. Projects include a police siren, electronic organ, sound effects unit, light chaser and many, many more!



- Suitable for ages 8+
- Softcover - full colour 96 pages. 205mm x 275mm

BJ-8502 $9.95

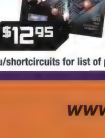
Short Circuits Project Kit
KJ-8504 $33.95

Short Circuits Book and Project Kit Package KJ-8502 $39.95

FROM $9.95

Short Circuits Book - Volume II

Once you have the basic skills and knowledge either from tackling Short Circuits Vol 1, you can now have some real fun! With this book (and associated project packs available separately) you can make such things as; a mini strobe light, police siren, mini organ, acoupole of powerful radio transmitters, an FM radio - evena 'Knight Rider' scanner!! All components are fully described and explained, along with tutorials on soldering iron and multimeter use. All projects are safe and battery powered.



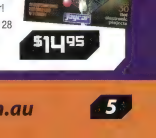
- Softcover - full colour 205 x 275mm.

BJ-8504

$12.95

Short Circuits Volume III

This is the definitive electronics training manual and presents more than 30 individual printed circuit board-based construction projects. Each project (available separately) contains a full technical description, with experimental changes to each circuit also explained. This book will give you the knowledge and skill that will elevate you into a fully fledged constructor!



- Softcover - full color 128 pages. 205 x 275mm

BJ-8505

$14.95

Check online www.jaycar.com.au/shortcircuits for list of project kits

Jaycar ARDUINO DEVELOPMENT KITS

Arduino Compatible Boards

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs (includes Jaycar stepper motors). Arduino projects can be stand-alone, or they can be communicated with software running on your computer. These Arduino development kits are 100% Arduino compatible. Designed in Australia and supported with tutorials, guides, a forum and more at www.freetronics.com. A very active worldwide community and resources are available with many projects, ideas and programs available to freely use.

LeoStick (Arduino Compatible)

A tiny Arduino-compatible board that's so small you can plug it straight into your USB port without requiring a cable! Features a full range of analogue and digital I/O, a user-controllable RGB LED on the board and an on-board Piezo/sound generator.

- ATmega32u4 MCU with 2.5K RAM and 32K Flash
- 6 analogue inputs (10-bit ADC) with digital I/O, 14 extra digital I/O pins

XC-4266

$29.95

"Eleven" Arduino-compatible Development Board

An incredibly versatile programmable board for creating projects. Easily programmed using the free Arduino IDE development environment, and can be connected into your project using a variety of analog and digital inputs and outputs. Accepts expansion shields and can be interfaced with our wide range of sensor, actuator, light, and sound modules.

- 8 analog inputs

XC-4210

$39.95

EtherTen, Arduino-compatible with Ethernet

Includes onboard Ethernet, a USB-serial converter, a microSD card slot for storing gigabytes of web server content or data, and even Power-over-Ethernet support.

- 10/100base-T Ethernet built in
- Used as a web server, remote monitoring and control, home automation projects
- 8 analog inputs

XC-4216

$69.95

USBDroid, Arduino-compatible with USB-host Support

This special Arduino-compatible board supports the Android™ Open Accessory Development Kit, which is Google's official platform for designing Android™ accessories. Plugs straight into your Android™ device and communicates with it via USB. Includes a built-in phone charger.

- USB host controller chip
- Phone charging circuit built in
- 8 analog inputs
- MicroSD memory card slot

XC-4222

$69.95

EtherMega, Mega sized Arduino 2560 Compatible with Ethernet

The ultimate network-connected Arduino-compatible board: combining an ATmega2560 MCU, onboard Ethernet, a USB-serial converter, a microSD card slot for storing gigabytes of web server content or data, Power-over-Ethernet support, and even an onboard switchmode voltage regulator so it can run on up to 28VDC without overheating.

- 10/100base-T Ethernet built in
- 54 digital I/O lines • 16 analog inputs
- MicroSD memory card slot
- Prototyping area
- Switchmode power supply

XC-4256

$119.00

ProtoShield Basic

A prototyping shield for the Eleven (XC-4210) and USBDroid (XC-4222). Provides plenty of space to add parts to suit any project, keeping everything neat and self-contained. Includes dedicated space to fit a power LED and supply decoupling capacitor.

- Gold-plated surface

XC-4214

$4.45

ProtoShield Short

A dedicated short version prototyping shield for EtherTen (XC-4216) and EtherMega (XC-4256). This special prototyping shield is designed to fit neatly behind the RJ45 Ethernet jack, allowing you to stack your Ethernet-based projects right on top with standard headers.

- Pads available to fit a reset button
- Gold-plated surface

XC-4248

$4.95

Mega Prototyping Shield

Fits the EtherMega (XC-4256) and Arduino compatible "Mega" size boards so you can fit your own parts for projects. Includes header pin sets.

- Over 300 general-purpose plated holes for your parts
- Handy 5V and GND rails
- All Arduino I/O header pins branched out for your use
- Gold-plated surface
- Reset button

XC-4257

$17.95

H-Bridge Motor Driver Shield for Arduino

DUE EARLY NOVEMBER

Directly drive DC motors using your Arduino compatible board and this shield, which provides PWM (Pulse-Width Modulation) motor output on 2 H-bridge channels to let your board control the speed, direction and power of two motors independently. Perfect for robotics and motor control projects.

- Drives up to 2A per motor channel
- All outputs are diode and back-EMF protected

XC-4264

$29.95

433MHz Receiver Shield

This receiver shield lets you intercept 433MHz OOK/ASK signals, decoding them in software on your Arduino. All the Arduino headers are broken out to solder pads, and GND and 5V rails are provided for convenience.

- Reset button
- Blue "power" LED
- Red and green user-defined LEDs
- Gold-plated surface
- 433.92MHz tuned frequency

XC-4220

$29.95

8 Channel Shield

Drive up to 8 relays from an Arduino using just 2 I/O pins. It communicates with your board using I2C, so you can even stack several shields together to drive 16, 24, or more outputs!

- Size: 52(W) x 66(H) x 12(D)mm

XC-4276

$34.95

Power-over-Ethernet Regulator

This regulator module fits onto the EtherTen (XC-4216) or EtherMega (XC-4256) to make them compatible with commercial 48V Power-over-Ethernet switches. It includes built-in smarts to communicate with the switch and negotiate a power rating for the device, then uses a switch-mode regulator to efficiently drop the 48V supplied via the LAN cable down to 7.5V for use by the Arduino compatible board.

- Implements the official 802.3af Power-over-Ethernet standard
- 48VDC in, 7.5VDC out
- 12.5W maximum power rating

XC-4252

$29.95

Power Regulator 28V (Switchmode)

This regulator is a high tech switchmode supply with a selectable 5V or 7VDC output. The input voltage range of 6 to 28VDC is very flexible and it will not overheat at higher input voltages like the 7805 and other linear regulators may.

- Up to 1A output current at selectable 5V or 7VDC output voltage
- Can also be used for the EtherTen and EtherMega Power-over-Ethernet for efficient switchmode supply remote powering
- Blue power LED
- 0.1" pitch standard header pads

XC-4258

$19.95

To order call 1800 022 888

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/11/12.

SIMPLE TO ADVANCED PROJECTS

N-MOSFET Driver & Output Module

This high-power N-MOSFET module lets you switch high-current loads using a tiny microcontroller. Works brilliantly for automotive projects such as switching high-power 12V lights and high wattage LEDs.

- Maximum 60V / 20A switched load
- Multiple connection headers for high-current wiring
- Built-in pulldown resistor to ensure output is off by default
- Drive directly from an Arduino digital output

XC-4244

$6.95

3-Axis Accelerometer Module

Easy to use 3-axis accelerometer that provides separate outputs for X, Y, and Z. Very simple to connect to an Arduino or other microcontroller using analog inputs, and easy to read the values into your program or circuit directly.

- Selectable +/-1.5g and +/-6g ranges
- Freefall-detection (0g) output
- Built-in 3.3V regulator with 5V-safe I/O lines

XC-4226

$19.95

Arduino Displays

LCD & Keypad Shield

Handy 16-character by 2-line display ready to plug straight in to your Arduino, with a software-controllable backlight and 5 buttons for user input. The display is set behind the shield for a low profile appearance and it includes panel mounting screw holes in the corners.

- 2 rows of 16 characters
- Supported by a driver library
- Software-controlled backlight
- Reset button

XC-4218

$29.95

Temperature Sensor Module

Sprinkle these around your house to collect temperature data using your Arduino. This 1-wire bus temperature sensor module is easy to connect and use. You can even daisy-chain several together on the same wire. 0.5°C accuracy and fast response.

- -55 to +125°C temperature range
- Selectable 9 or 12 bit precision
- Arduino compatible library and examples support
- Unique device ID coded into every sensor
- Two sets of header connections to allow easy daisy-chaining

XC-4230

$16.95

Logic Level Converter Module

This module easily connects different logic voltage levels together for bi-directional communication on up to 4 channels, allowing you to use low-voltage sensors with a 5V microcontroller.

- 4 bi-directional channels
- Easily connect 3.3V sensors and devices to 5V microcontrollers
- Pass-through GND connection

XC-4238

$6.95

Large Dot Matrix Display Panel

A huge dot matrix LED panel to connect to Eleven (XC-4210), EtherTen (XC-4216) and more! This large, bright 512 LED matrix panel has on-board controller circuitry designed to make it easy to use straight from your board. Clocks, status displays, graphics readouts and all kinds of impressive display projects are ready to create with this display's features.

- 32 x 16 high brightness Red LEDs
- 5V operation
- Viewable over 12 metres away
- Tough plastic frame
- Controller IC's on board, simple clocked data interface

XC-4250

$39.95

NOTE: Can for comparison only.

Hall Effect Magnetic & Proximity Sensor Module

Sense magnetic presence, rotating wheels and magnets, door and arm sensors, and anything else magnetic nearby this sensor.

- Green "triggered" LED for easy setup and use
- Output turns on at 40 Gauss (4mT) and turns off at 30 Gauss (3mT)
- 2.5 to 5.5V operation

XC-4242

$9.95

Shift Register Expansion Module for Arduino

Use this shift register expansion module to drive up to 8 devices using just 3 pins on your microcontroller. They can also be daisy-chained together to drive 16 channels or more.

- 8 output channels per module
- 2 to 6V operation
- Blue power LED

XC-4240

$6.95

OLED Display Module for Arduino

High resolution, full colour OLED display module! Perfect for graphics, gauges, graphs, even make your own video game or interactive display.

- 16,384 full colour RGB pixels in a 128 x 128 format
- Active display area 28.6 x 26.8 mm, (1.5 inch diagonal)

XC-4270

DUE EARLY NOVEMBER

$49.95

Full Colour RGB LED Module

Includes a bright RGB LED on the top of the board and a WS2801 constant-current, addressable, multi-channel LED driver on the back. This smart module can be daisy-chained, so you can connect a number of these together in a string and drive each of the module colours individually from your microcontroller. The WS2801 includes its own built-in PWM outputs.

- 3.3 to 5V operation
- Constant current controller

XC-4234

$9.95

Sound & Buzzer Module

This versatile piezo-element module can be used for both input or output! Also used as a noise-maker driven by your microcontroller for audible feedback of events, and as a knock-detector input to sense events and react to them. Includes a built-in 1M resistor to allow the piezo element to detect shocks.

- Frequency response 0-20KHz, peak resonant frequency: 4KHz +/-500Hz
- Sound pressure level at 10cm: 75dB (min)
- 1 to 25V rated voltage (3 to 5V typical)

XC-4232

$9.95

Microphone Sound Input Module

Give your project ears with this sound response and sound pressure level sensing module. An integrated dual signal amplifier converts the sound to separate channels for pulse and frequency measurement, and sound volume level. Designed to connect straight to an Arduino compatible, microcontroller Analog to Digital converter or many other circuits.

- Omnidirectional microphone
- Frequency response 60Hz to 15KHz
- Sensitivity -40dB typical

XC-4236

$9.95

4 Channel PoE Midspan Injector

Power up to 4 EtherTen's or EtherMega's with DC from a low cost plugpack across your home or office network cables. This takes all the hard work out of cutting and hacking ethernet cables to power remote boards, it isolates and powers the correct wires automatically.

- 4 channels of input/output jacks
- Can be connected directly and powered by standard network cables on the output side Commercial
- Power-over-Ethernet sources are not required
- Blue power LED
- Mounting holes

XC-4254

$26.95

Real-Time Clock Module

Perfect for clock projects, dataloggers or anything that needs to know the date and time. Keeps accurate time for years using a tiny coin-cell, and is very simple to connect to your Arduino project. A driver library allows your program to easily set or read the time and date.

- Battery included

XC-4272

$29.95

PARTY TIME AT JAYCAR

LED Linkable Party Lights with Controller

Glam up a party with these linkable blue, amber and red LED party lights. They'll switch in time with the beat and the microphone sensitivity and light chaser speed are fully adjustable.

- Mains powered

3 LED Light
- Size: 140(L) x 130(W) x 480(H)mm

SL-2911 $49.95

6 LED Light
- Size: 350(L) x 130(W) x 360(H)mm

SL-2913 $79.95

FROM $49.95

8 Ch Mixing Console with Digital Effects

A well-featured little unit with high and low mic inputs, separate EQ, gain and pan controls, aux send and return for effects, recording outputs and phantom power. The ideal small mixer for home recording!

- Four mono channels with high & low impedance inputs
- 2-band EQ on all mono channels
- 2 stereo channels
- LED master level indicator
- Size: 270(W) 270(H) x 50(D)mm

AM-4204 *was $249.00*

$229.00 SAVE $20

DJ Mobile 19" Rack Frame

Completely portable! Ideal for DJs, PA techs, sound engineers or guitarists with large rack setups. The top section can be rotated through a range of 45° for maximum flexibility.

- Steel construction
- Hardware included
- Size: 530(W) x 1050(H) x 500(D)mm

HB-6348 *was $79.00*

Hurry! Limited stock.

Accessories not included

$69.00 SAVE $10

Active Column Speakers

Provide excellent directivity through the three 4" full range drivers installed. Features a built-in amplifier and provides 20WRMS of power to each speaker unit. RCA inputs for audio source connection. Mains IEC leads included.

$249.00 SAVE $50

TV not included

- Finished in glossy white paint
- Mains powered
- Size: 532(H) x 113(D) x 131(W)mm

CS-2439 *was $299.00*

SOLD AS A PAIR

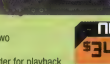
DVD/CD Player with 5 Disc Changer

A feature packed DVD Player that provides countless hours of playback without having to change discs. Features a 5 DVD/CD changer which enables to load 4 discs while the other one is playing.

- Mains powered
- Karaoke function with two microphone inputs
- USB, SD/MMC card reader for playback
- HDMI, component and composite video output
- Digital & analogue audio output connectivity
- Size: 496(L) x 416(W) x 152(H)mm

AA-0489

NEW $349.00



900W DMX Fog Machine

Hook this fog machine up to your DMX512 controller for total customisation of your stage/party effects. Fog can burst with the beats or waft at certain intervals and durations.

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- Remote included
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AF-1213

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1L Fog Juice to suit available separately AF-1212 $17.95

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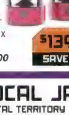
Pop this pair of speakers in the backyard and the 2.4GHz DIGITAL audio transmitter will send crystal clear audio to the units up to 30m away. Each speaker has its own power adaptor and operates wirelessly. Power adaptor for transmitter and speakers are included, however speakers can also be powered via 6 x AA (not included) for complete portability.

- Speaker size: 250(H) x 130(Dia.)mm

AR-1891 *was $169.00*

$139.00 SAVE $30



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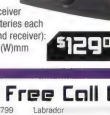
- Size (transmitter and receiver): 156(L) x 45(H) x 95(W)mm

AR-1895

$129.00



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SERVICEMAN'S LOG

Un-bricking a Samsung smartphone

Remember the cartoon of the frog about to be swallowed by a stork? The frog is valiantly choking the bird with its front legs so it can't swallow and the accompanying caption was "never ever give up!". Well that's what it was like when it came to un-bricking the Samsung smartphone I fouled up on recently.

Items Covered This Month

- Un-bricking a Samsung Galaxy smartphone
- The iPhone that swam in Coca-Cola
- False-alarming security system
- Resurrecting an ancient Fender Champ guitar amplifier

**Dave Thompson, runs PC Anytime in Christchurch, NZ.*

Regular readers will know that I've spent the last few months doing battle (off and on) with a "bricked" Samsung Galaxy smartphone (ie, a phone that had been rendered useless by a software update that went horribly wrong). And when I say "doing battle", that's exactly what I mean because numerous attempts at un-bricking what had become an expensive paperweight had left me with egg all over my face.

Of course, I really only had myself to blame. After all, I was the smart-alec who had bricked the phone in the first place!

Those with total recall will remember that my main challenge in resurrecting this unit was how to connect a programming box of tricks I'd purchased for the very purpose. Once I'd achieved that, I would then be able to flash enough data into the phone's ROM to get it to boot into a state I could do something with; or at least, that was the theory. In the vernacular of phone-geeks, I would be able to "un-brick" it.

The good news was that Samsung made provision for just such a connection. The bad news was that this-so-called "JTAG" point consisted of a series of DIL pads designed for a tiny 12-pin header connector, which was not included. With a pin pitch of just 0.4mm, each row of six pads covered just 2mm on the board, making it smaller than anything I'd ever worked on before.

In fact, I could barely even see the pads let alone connect wires to them. This is where my illuminated magnifying headset really came into its own; without something like this, working on such small components would be impossible.

In order to make the necessary connections, a friend and I had brainstormed the design of some programming adaptor jigs. He was going to turn them out on his laser-engraving machine. The problem was getting the laser fine-tuned enough to drill two rows of holes just 0.15mm in diameter but it turned out that the laser could do that standing on its head.

Our idea was to make a jig from some clear acetate sheet, shaped like a butterfly. Rows of holes in the centre of the jig would match the DIL pad pattern in the phone and I could then thread 0.13mm wires through these holes and run them off to larger pads spaced far enough apart in the "wings". I would then be able to easily solder heavier wires to these thin wires and run them to my JTAG programmer.

After that, it would simply be a matter of clamping the jig onto the pads and the wires would make the necessary contacts.

Well, it all sounded fine in theory but when the jigs arrived and I saw how tiny everything was, I began to have serious doubts. I had to try though so I stripped the insulation from some

...WITH THE AID OF MY MAGNIFYING HEADSET & A PAIR OF NEEDLEPOINT TWEEZERS

multi-core hobby wire and used the individual 0.13mm strands from that to thread my jig. It was all a bit fiddly but with the aid of my magnifying headset and a pair of needle-point tweezers, I soon had each row of six holes wired up.

However, I had to be careful not to pull the strands too tight for a couple of reasons. First, the wire was very fragile and easily broken and second, too much tension pulled the tiny jig out of shape.

When I finally had the jig wired, I tried to fit it onto the pads. But while I could position it correctly, it would immediately twist off to one side or the other each time I tried to clamp it.

After several abortive attempts, it quickly became obvious that this was just not going to work. The theory was good but in practice it just didn't work out.

At this point, I was so disappointed and frustrated that I was ready to chuck it in and put it down to experience. But the fact that others were doing this successfully to the same phone drove me to look once again at sourcing the headers the circuit board was designed for. If you recall, I had gone down this road before only to find that they were not available in New Zealand. And all the companies that sold them online wanted a minimum of $US30-50 to ship one to me.

You could fit 30 of these headers in a matchbox, so charging that much for shipping was just a rip-off. Most of these companies also had a minimum spend of $30 and given that the parts I wanted were just 89 cents apiece, I'd need to buy quite a few of them plus a lot of stuff I didn't really need just to reach that dollar value.

As a result, I emailed every vendor I could find advertising either these Molex or Panasonic headers and asked them to make an exception to their minimum order and/or minimum shipping costs. Not one of them would budge so I got nowhere and on principle, I will now never buy anything from any of them in my lifetime.

However, one company did at least apologise and advised me to contact an Auckland-based company that may be able help. I contacted them and to my delight discovered that they could supply the Panasonic male and female headers I needed and would only charge a few dollars for shipping. I would still need to spend at least NZ$30.00 but I considered this to be a reasonable compromise.

I purchased several of these male and female connectors in case I made a mess of things and while there, ordered some surface-mount solder compound. I have almost zero surface-mount soldering experience, other than tackling the odd suspect dry-joint, so the thought of soldering these connectors in place was giving me sleepless nights. I searched the web and read up all I could about the subject and figured that with the right soldering tools and this recommended soldering compound, I should be OK.

Cold feet

The package arrived a few days later and when I saw the headers in the flesh, I got cold feet again. They were even smaller than I had imagined. However, the flux compound had excellent instructions on how to use it so I told myself I could do it and set about getting everything prepared.

First, I cleaned the circuit board and pads with isopropyl alcohol and applied a microscopic amount of the flux, which comes in a syringe, onto each pad (or as close as I could get to them). I then orientated and placed the header connector using a pair of tweezers, pressing it as tightly as I could onto the pads. After then nudging it into place with the tweezers, I took a deep breath, cleaned and tinned my smallest soldering-tip and touched the corner pin. Solder instantly flowed into and welded nearby pins to their pads underneath. I could scarcely believe it.

A few touches of the soldering iron tip to the remaining pins had the header soldered beautifully. I checked out my work with my high-magnification jeweller's loupe and it looked perfect, with no bridges or dodgy-looking joints. I readily admit that it had nothing to do with any great skill on my part; it was all due to that solder flux.

It certainly cured my previous reluctance to work with surface mount technology on future projects.

But having the header connected to the board was only a third of the battle won. I still had the problem of connecting my JTAG programmer to it. I would have to use the matching female header for that and that would have to be soldered to a board of some kind which would then connect to the programmer.

During my internet travels I remembered a guy who had built his own expansion boards and I figured I'd have to make something similar. The board I'd need would look like a spider, with the pads for the header being the body of the spider and "legs" leading from each pad to larger solder pads for heavier-gauge expansion wires.

I've made hundreds of boards before but nothing on this minute scale. I doubted that my laser printer could even print a 0.125mm line and even if it could, there was the question of whether my basic photo-etching set-up would be capable of producing the board. There was only one way to find out and that was to try.

I use DipTrace to draw schematics and design circuit boards. I fired it up, found the pads to suit in the software's pattern library and set about designing the board. It all looked easy as I zoomed the pattern size up on my 24-inch widescreen monitor.

Once I had the DIL pattern in place, I created 12 normally-sized pads to solder the programmer's wires to and ran the various traces between. However, when I shrank it down to normal size, it just looked like a blob in the middle of my screen with no discernible

features. However, I went ahead and printed it out actual size and it actually looked great, with clearly-defined traces, pads and holes. At least the printer was up to the job!

I then printed it out on the clear acetate sheet I usually use for making PCBs and it too looked good. I use Kinsten-brand materials for making all my circuit boards so I found a tiny offcut, lined up the acetate and exposed it in my lightbox. I then developed it carefully using a weaker-than-usual solution of developer and etched it in my tank.

The resulting board measured just 9 x 10mm and it looked perfect. Nevertheless, I used a multimeter to check that each header pad connected to its corresponding expansion pad and that there were no bridges between the pads.

That done, I carefully soldered the female header onto my expansion board, using the same technique described above, and this too was successful. I then soldered the programmer's leads to the relevant expansion pads.

Re-flashing the phone

It took a little prodding with a needle file to get the adaptor board to fit the new JTAG header but it soon clicked home. And with that, I was finally ready to try my first dead-phone resurrection.

I connected the programmer to my computer, plugged in the expansion board connector and connected that to the phone. After loading the software and ensuring the correct files were loaded, I held my breath and hit the button. The information window gave me a running commentary of what was going on but before I had even finished reading the entries, the process was completed.

It had all been unbelievably quick but each separate process was followed by "success" and at the end it said everything had been done so who was I to argue!

I wasn't out of the woods yet though; I still had the last phase of the process to go. What I had done so far was to flash the basic boot ROM to the phone, allowing it to be placed in the "download" mode. This would now enable me to re-load the original operating system and applications.

Basically, a "soft-bricked" phone will not boot but will it still go into download mode. My phone had previously been "hard-bricked" because it would neither boot nor go into download mode. So now came the acid test.

I went through the download mode procedure and lo and behold, the little yellow Android man appeared on the screen, indicating that the phone was ready for flashing. However, my sense of accomplishment was tempered by the fact that I still had to install the operating system and various applications and the phone had been bricked during a legitimate software update in the first place.

My next problem was getting my computer to recognise the phone. This had been an issue when I had originally tried connecting it to my computer, which is why it probably ended up bricked in the first place.

At that time, I eventually found some drivers that worked but now no matter what I did, I still ended up with the dreaded "Unknown Device" entry in the Windows Device Manager. So until I could get the computer to correctly recognise the phone, I couldn't complete the ROM flashing process.

I tried every possible driver and even different computers with other versions of Windows but all to no avail. The gurus on the online technical forums had no ideas either and I was quickly becoming more than a little frustrated. It seemed as if I'd wasted all this time and money only to fall at the last fence.

The general online consensus was that because the phone was bricked, the original driver couldn't recognise it. Some experts suggested that I try the Android developer drivers which are generic and should get most devices to be at least "seen" by Windows so I downloaded and tried them. However, it was still "no go".

Eventually, out of desperation and with no other ideas, I thought I'd try another USB cable. The one I had been using was the one that came with the phone and I'd discovered from working with other phones that even though cables may look the same, they are not always interchangeable.

Changing the cable really was clutching at straws and I would have bet my

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next pay cheque that it wouldn't make any difference, so you can imagine my surprise when the computer informed me that the driver had been successfully installed! I quickly started my flashing software and received confirmation that COM5 – the port used to communicate with the phone – was now open and waiting.

With one mouse click, the new system software began uploading to the phone, with the phone then rebooting in less than 60 seconds. And up came the familiar boot screen and sounds. Success!

So my persistence paid off in the end but what a battle. The cable swap made absolutely no sense but no matter; stranger things have happened when it comes to servicing. In fact, I have now gone back to using the original cable and everything works as it should.

It just goes to show that when you've exhausted all other possible options, it's often worth trying something outside the square, no matter how unlikely the chances of success.

In the end, the experience proved invaluable and I gained some necessary skills to tackle this sort of problem. What's more, as word got out that I'd successfully resurrected my phone, various servicing jobs involving phones and tablet computers began to trickle in.

It's all a result of my original plan to diversify my business, so un-bricking my phone was well worth the effort!

Fixing an iPhone 4

How many mobile phones have come to a premature end because they took a bath? A. P. of Toowoomba, Qld recently resurrected an iPhone 4 that went swimming in Coca-Cola. Here's what happened . . .

This story began when my friend Sally called to tell me that her iPhone 4 had met with an accident. Apparently, she had put an almost-full bottle of Coke Zero into her bag, along with her iPhone. Unfortunately, the lid of the Coke bottle wasn't properly screwed on and the contents leaked out.

But that wasn't the end of her misfortune. The bag was watertight, so the iPhone took a real dunking. Sally didn't notice the problem for several minutes and when she finally fished the phone out, it had shut down and wouldn't come back on.

Sally couldn't bring me the phone for a few days. So was there anything she should do in the meantime, to prevent further damage?

The advice in several online forums to recover a mobile phone that has been immersed in water is pretty straightforward. This involves removing the battery and placing the phone in a jar of uncooked rice for an extended period of time, so that the rice absorbs the moisture evaporating slowly out of the unit. That's probably good advice for a phone that's been immersed in clean, fresh water but soft drink is going to leave a sticky residue that will lead to corrosion.

I toyed briefly with the idea of asking Sally to immerse her phone in fresh water, to wash out the Coke, but quickly rejected it on the grounds that the battery was still connected. I also had no idea how much Coke had made its way into the phone and immersing it in water could do more damage. So the phone went into some rice for three days before coming into my hands.

I resisted the temptation to turn the phone on because that could have caused further problems. Instead, I paid a visit to the **iFixit.com** website where I knew I could find comprehensive guides to replacing any part of an iPhone 4. My plan was to dismantle the phone and clean out any liquid or residue that I found.

I had previously purchased a replacement iPhone 4 part on eBay and this came with a set of tools necessary for working on the phone. These tools were a pentalobe screwdriver for removing the two pentalobe screws that hold the back on, a size 00 Phillips screwdriver for the remaining multitude of tiny screws in the device, a small flat screwdriver for removing a single stand-off that didn't have a Phillips head, and a plastic "spudger" for prying off the thin steel covers over various parts, as well as prying off the many flat ribbon connectors.

I supplemented these tools with some tweezers, a magnifier, two empty egg cartons which served as screw trays, a steady hand and infinite patience.

Before commencing the disassembly, I peered into the headphone socket of the phone with the help of a LED torch and saw that the semicircular liquid contact indicator at the end of the headphone socket had turned pink. This meant, at the very least, that liquid had made its way into the headphone socket.

I followed the instructions on iFixit for replacing the display, because this results in the phone being almost completely stripped down. I began by removing the pentalobe screws from either side of the dock connector. The back could then be slid up by a few millimetres and lifted free.

The first thing I noticed inside the phone was that the two internal liquid contact indicators had also turned from white to pink. I could also see that there was still some moisture adhering to the inside of the back, the battery and the steel shields on the logic board. Later, when I had the front panel off, I could see that there was moisture between the back of the display and the chassis.

In this model, the display is glued to the front panel and cannot be removed without being damaged, so that was as far as I was able to go.

My next step was to carefully examine the logic board but it seemed to have been untouched by the liquid. This was good news as it is quite expensive to replace. Sure, most of it is covered by metal shields but I couldn't see any evidence of moisture near the edges of these shields. I was afraid that removing the lids from the shields might damage them, so I left them alone.

Having dried up the remaining

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Please be sure to include your full name and address details.

moisture during the disassembly and not having seen any signs of corrosion or staining near any conductors, I now carefully reassembled the phone. The instructions on iFixit make it clear that grease from one's fingers on any of the mating shiny metal surfaces can compromise either the shielding or the operation of the WiFi antenna (which doubles as a retainer for the flat cable connectors on the logic board). As a result, I diligently swabbed all shiny metal mating surfaces with alcohol to eliminate the possibility of contamination with finger grease.

With the phone back in one piece, the moment of truth had arrived. I pressed the power button and . . . nothing happened! Maybe the battery was flat? I connected a charger to the phone and waited but still nothing happened.

Sally particularly wanted me to rescue the photos and videos from the phone, so as a last-ditch effort I connected the phone to the USB port of a computer to see if it would at least let me access the phone's file system.

And this time it worked – the display came on showing the warning icon for a very flat battery. And then, several minutes later, the phone started up normally and appeared to be fully functioning, in the process receiving a backlog of texts and notifications.

I tested the cameras, the vibrator, the WiFi, the volume buttons, the home button, the speakers and the microphones, and they all worked fine. I even managed to copy all the photos and videos off the phone through the USB connection to the computer. The only aspect of the phone that wasn't 100% was the display, which had some brown staining near the bottom.

Next, I tested the Sleep On/Off switch by briefly pressing it. The display immediately went dark and nothing I could do would bring it back. I then tried connecting the phone to the charger again for a few hours but nothing happened. I connected the phone to the computer again and again it came good. And then, a few hours after that, it died again and nothing would bring it back.

Disappointed at this turn of events, I then began to consider some possible causes for these symptoms. Apart from the possibility of a logic board problem, it seemed logical to assume that the Sleep On/Off switch might have become intermittent, due to its contacts having been contaminated by the liquid. I was also concerned about the dock connector, as I couldn't see into it well enough to confirm that its gold contact fingers were clean.

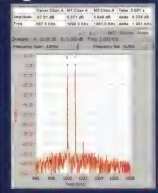
As a result, I decided to replace both these parts and so I bought a "Power/Sleep On/Off Switch Button/Proximity Light Sensor Flex Cable Part" and a "Dock/Home Connector Charging Flex Cable with Microphone". These parts cost about $19 from an eBay seller.

Replacement of the dock connector went smoothly but not so for Sleep On/Off switch. Its replacement required removal of the headphone socket and some flat cables and I somehow tore the cable running to the headphone socket. I therefore had to order and replace the "Headphone Audio Jack Volume Mute/Silent Switch Button Flex Cable", which cost $14.

While waiting for the replacement headphone jack assembly to arrive, I took a closer look at the logic board and found something that I had missed earlier – a small spot of residue and corrosion on a couple of pads near the entrance to the SIM card socket. I speculated that because these pads were fully exposed, not soldered and close to

What do you need?

High Resolution?



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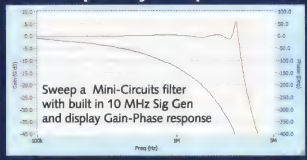

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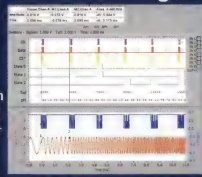
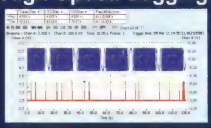


High Speed Logging?



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the opening for the SIM card drawer, they might be part of an electronic arrangement designed to shut the phone down when exposed to liquid.

I swabbed the residue and corrosion away with a cotton bud dipped in alcohol. One of the pads and its connecting trace were still somewhat discoloured after this procedure and I crossed my fingers that there was no permanent damage.

Almost all the rest of the logic board was enclosed by four shiny steel shields. Now that I had found evidence of this board getting wet near the SIM card socket, it was obvious that I would have to remove the lids from these shields, to see if any liquid might have found its way inside them. Unfortunately, the lid on one shield seemed to be welded around half its edge, preventing its removal, but the lids on the other three were held in place entirely by spring tension.

I gently prised these lids off and found some powdery-looking residue between a resistor and an inductor under one of them. This was also swabbed away with alcohol.

When the replacement headphone jack assembly arrived, I installed it and reassembled the rest of the phone. Holding my breath and crossing my fingers, I pressed the power button at the top of the phone. This time, the phone came on normally, without the help of a charger or computer USB port, and the battery showed a 68% charge. I then re-tested the various facilities and all seemed to be working.

My elation was to be short-lived. At the end of these tests, I put the phone on charge to completely recharge the battery. And once it reached 100%, the phone shut down and wouldn't turn on again.

I vowed that I wasn't going to let this thing beat me – at least, not yet. I removed the back, disconnected the battery and put the phone to one side while I figured out my next step.

In the end, I decided to do something that I should have done at the very beginning – fully immerse the logic board in clean water to wash away any hidden Coke residue. I followed the 19 iFixit steps to remove the logic board, then prised off the three removable shields. That done, I thoroughly swished the board in filtered rainwater and wiped every exposed square millimetre with a cotton bud, with the aim of encouraging any Coke residue to dissolve.

I then shook the board until no more drops would come out and dried it superficially with a tissue. It was then put aside overnight and the next day, I sat it on a sunny window-sill for a few hours to let it dry thoroughly.

Finally, I reinstalled the logic board in the phone and this time everything really was back to normal. It now worked without shutting down but what a saga.

So what would I do differently next time? Rushing to replace the power switch and the dock connector now seems wrong in hindsight. Having read stories about iPhones that have survived after being dropped into swimming pools or salt water, or been washed with laundry detergent in a washing machine, I would now be less squeamish about washing the whole thing with fresh water and then just letting it dry out.

I suspect that Apple has incorporated circuitry to reduce battery current to almost zero if liquid is detected, so these scenarios are not as dire as they may seem. My preferred action would be to remove the battery, speaker, vibrator and cameras and wash the remaining parts in fresh water. I would then use gentle heat to speed the drying process, remembering that there could also be water trapped in the tiny spaces under those large chips which would have to evaporate out.

False-alarming security system

Security systems that routinely false-alarm can be a real pain in the neck. Here's how G. C. of Tawa, NZ solved one particularly persistent false-alarm problem . . .

I look after an elderly but still serviceable security system protecting a museum site's workshop and vehicle storage areas. Over the years (and even prior to my involvement), this system generated so many false alarms that an alarm activation call in the middle of the night would usually be ignored until the next day – that is, until I took over.

This was not good. If there had been a genuine break-in (and there was at least one attempt to my knowledge), then the alarm may have gone unanswered.

When I took over the system, I became the unfortunate person who was first on the call-out list. As a result, the security monitoring staff would telephone me at all hours of the night, advising that the alarm had gone off. This was a real problem in the early hours of the morning because my wife was woken as well. So my scarce "brownie points" were being used up fast!

This particular security system uses a number of motion detectors to protect areas inside "rough" buildings with unlined walls. All the zone detection circuits on the control unit are used, with multiple motion detectors wired to each one. As a result, it was difficult to determine which individual detector had activated to cause a false alarm, although it was possible to determine which zone had activated.

I tried all sorts of things to eliminate the false alarms, including a battery-backed regulated power supply to supply the motion detectors, as it was noticed that some false alarms occurred during mains power supply outages. However, that didn't stop the false alarms.

Next, I fitted wooden shades to keep the light from the roof skylights away from the detectors. This certainly helped reduce the false alarms as the light changed but they weren't eliminated altogether.

Two of the detectors connected to zones which were subject to false alarms were combined microwave/PIR types and I suspected that these were the main culprits. The microwave detection part was very sensitive to movement but the PIR detector was difficult to trigger except when a human was standing in direct view of the unit. So what could be causing these units to false trigger at night?

Eventually, I decided that the only way to solve the problem was to determine which individual detector of a multiple set had triggered. The wiring to these motion detectors was run using standard 6-core security cable, providing the power supply (two wires), the "end-of-line" resistor detection circuit back to the control panel (two wires) and a common "end-of-line" resistor "tamper" circuit (1-2 wires).

In the end, I determined that a

Resurrecting An Ancient Fender Champ Amplifier

R. D. of Lara, Victoria, recently resurrected an ancient Fender guitar amplifier with valves. Here's how he tells it . . .

The Fender Champ guitar amplifier (introduced in 1948) used just one valve in the output stage, arranged in a single-ended class-A configuration (about 5W). I had one come in recently, the owner complaining that "it smells", which makes a nice change from "it blows fuses".

This one was a Silver-Faced Champ with the AA764 circuit and I started to get a bit nostalgic. This amplifier was around when Jimi Hendrix was strutting his stuff.

After removing the amplifier from its case and setting it up on the bench, the problem was immediately obvious. The screen grid resistor was a charred mess, completely unrecognisable from its original state, and the smell was really quite bad.

My first thought was that maybe the output valve, a 6V6GT, was dead. But first I replaced the screen grid resistor which, according to the circuit schematic was a 1kΩ 1W unit. I replaced it with a 5W resistor and then powered the unit up to test it, as I would now have to order in a new valve if this was faulty. It still didn't work, with no output from the amplifier whatsoever.

As a result, I began checking the circuit voltages and found that the screen grid resistor I had just replaced had around 300V across it! In normal operation, this should be just a few volts. This meant that the output valve was definitely dead, the screen grid having developed a short.

I left it alone for a few days until the new valve arrived. This was then installed and I powered the amplifier up again but it still didn't work. The voltage across the screen grid resistor was still quite high, though not as high as before, which meant that there had to be another fault lurking somewhere.

Well, the answer became apparent only after I had disconnected all the leads from the tag strip that held the screen grid resistor and I checked the resistor itself. It measured close to 1MΩ instead of 1kΩ and I could only put this down to the fact that I had initially tested the amplifier with the dodgy valve still in place. As a result, the output stage drew so much current that the new 1kΩ screen grid resistor had gone high resistance, although it still looked perfectly OK and there was no discolouration.

Replacing this resistor yet again fixed the problem and the amplifier sprang back into life.

With modern day valve amplifiers, this situation would not have arisen because the high-voltage (HT) rail is fuse-protected. So, as a safeguard against further failure, I fitted a fuse between the HT rail and the anode of the 6V6 valve. That way, if the valve fails in the future, the amplifier will just die in a very uneventful way instead of also burning the screen grid resistor to death – although I'm sure the ghost of Jimi Hendrix would prefer the latter.

simple transistor latch circuit with a local indicating LED could easily be installed inside each motion detector's case and powered from the detector's 12V power supply circuit. When the NC (normally-closed) relay contact in the detector opened, this could trigger the LED indicator circuit and provided this circuit had a high enough impedance, the alarm system would function normally.

The real difficulty was figuring out how to stop these LED indicators from latching during the day when the building was occupied. I certainly didn't want to have to install any more cabling to do this, as the building runs were quite extensive.

The solution was to reset each latched LED circuit by using a connection to the tamper circuit. The idea was to detect the change in voltage when the tamper circuit was open-circuited at the control unit. Provided this reset connection was of high enough impedance, then all the installed LED indicators could be wired in parallel across the tamper circuit.

A wiring trial indicated that this arrangement would work well. All I had to do now was figure out how to disable this reset circuit late every afternoon, when the security control unit was armed for the night.

In the end, the solution was relatively simple. In this system, a security flap is used to hide the separately located keypad panel near the entrance from prying eyes. The site protocol was that this flap had to be locked "closed" after the control unit was disarmed at the start of each day. It was then opened at night to arm the unit.

As a result, I simply extended the tamper circuit to the keypad panel and used a microswitch to detect when the flap was closed. This scheme effectively prevented all the indicating LED circuits from latching on during normal building-occupied operation while allowing them to work at night when the flap was open. With that in place, I was set to determine which motion detector on a particular zone circuit had triggered a false alarm.

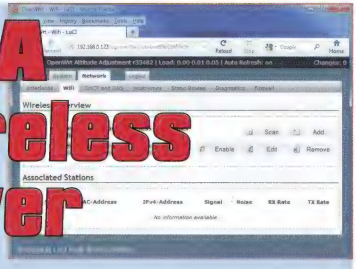
After a few late night-time trips to the site after false alarms, a pattern soon became evident in regard to the environmental conditions prevalent at these times. In particular, one PIR sensor that was prone to false triggering was located at the southern end of the building, which is exposed to very cold winds, especially during winter.

Finally, the reason for the false triggerings became clear – a PIR detector is sensitive to fast moving air with sharp temperature gradients in its area of surveillance. And when the cold wind blew strongly enough through the rather large cracks between the large entrance door and the door posts, the sudden temperature changes due to air movement were sufficient to trigger the detector.

The cure was simple – I blocked off the door cracks with timber and the false alarms ceased. It was much the same story for the other motion detectors that were causing false alarms.

So that solved the false alarm problems – at least during winter. Now all I have to do is figure out how to keep birds out of the building during the spring nesting period. If I can do that, there should be no more false alarms to disturb my sleep. SC

Hacking A Mini Wireless Webserver



For about $30, you can have a tiny, low-power web/email server with WiFi, Ethernet and USB. And with a bit of extra circuitry, it can even monitor voltages and control some relays.

Pt.1: By ANDREW SNOW

WOULD YOU LIKE a wireless web server that consumes almost no power and can be easily interfaced to other circuitry? The Webserver in a Box (WIB) project published in SILICON CHIP from November 2009 to January 2010 has been very popular but it lacks a WiFi interface. It's also rather limited in regards to other capabilities; for example, the WIB has no support for DHCP (Dynamic Host Control Protocol) which allows for automatic IP address allocation.

If you hack a TP-LINK TL-WR703N router, you can overcome all these problems. It's sold as a tiny "G Travel Router" but you can easily re-flash it to run a version of Linux. It's then a relatively simple matter to set up a web server, an email server and so on. This is dramatically smaller and cheaper than a typical PC and it does all this while drawing about 1W of power!

Consider what this means; not only can you run a low-traffic website off this device, you can monitor temperatures, switch devices on and off and so on, without even needing a wired network connection. All you need is a source of low-voltage DC power and wireless internet access, plus the re-flashed WR703N.

The TL-WR703N is actually a fully functional miniature computer, shipped with software to make it operate as a 3G/WiFi router. This device is available from Hong Kong on eBay for only $25 delivered to Australia, making it a good choice for the home experimenter. Just go to the eBay website and type "WR703N" into the search box.

Making some mods

What's the catch? Because TP-LINK made this device for their domestic market, its default user interface is in Chinese. We'll show how you can remove its built-in firmware by installing Linux over the top, without having to learn a new language. All you need are some basic computer skills and a general understanding of computer networking concepts.

Inside the WR703N's tiny 57mm square plastic case is an Atheros chipset containing a MIPS-based CPU, 802.11b/g/n 150Mb wireless (WiFi), 4MB of flash storage and 32MB of RAM. As well as its USB2.0 and 100-base-T Ethernet ports, the only other port is a Type B micro-USB socket by which the device is powered (a suitable USB cable is supplied with the device).

Note, by the way, that the WR702N model is not suitable. It's similar to the WR703N but only has 2MB of flash memory and 16MB RAM.

Nominally running off 5V, the WR703N's average power

Fig.1: this screen grab shows the menu item (circled at bottom left) that must be selected in the WR703N's web interface to upload the OpenWRT firmware. It's then just a matter of clicking the button to the right of the text input box to bring up the file "chooser" dialog.

Fig.2: the next step is to select the OpenWRT firmware file that you downloaded in Step 3 and click the OK button. You then click the OK button again in the next dialog box to confirm the file selection and start the new firmware installation process.

consumption (with no USB device attached) is only 0.5W but it can draw more than double that when the CPU & Wifi are being used. Enthusiasts on the internet say it will work with an input voltage as low as 3.7V, meaning it can be run straight off a single Lithium-Ion cell. In fact, TP-LINK did this with the similar but more expensive TL-MR11U model, which comes with a built-in 2000mAh cell.

To install Linux, first you'll need to download new firmware from the Internet, then connect your computer to the WR703N to upload this new firmware.

There is more than one version of Linux that can run on the WR703N but we've chosen to use OpenWRT, a free Linux distribution for embedded devices. It has extensions which let you still use your device as a wireless/3G travel router if you wish but extends its capabilities far beyond this. It can even be loaded with various scripting languages which allow you to program it to do just about anything.

Once OpenWRT is installed, then depending how you configure it, it can operate as a web server, as a file server, play audio via a USB sound card and, for those with the technical knowledge, even do such things as run a telephone PBX for Voice-over-IP (VoIP) phones.

This month, we'll show you how to install the new firmware, configure the networking parameters and do the web server set-up. A follow-up article will then describe how to interface some hardware to control relays and to measure temperatures and voltages. We'll also describe how to set up an email server in the follow-up article.

Other requirements

In addition to the WR703N, you'll need a PC with an Ethernet port and a standard Cat5 (or Cat6) Ethernet cable. You also need to initially connect the device to the internet via Ethernet, which means you need an internet modem/router with a spare Ethernet port. This is to allow it to download some of the new software itself.

OpenWRT installation steps

STEP 1: make sure your computer can run "Telnet" from a command prompt. If you have Windows 7, it has to be

Fig.3: a progress bar monitors the firmware installation. Do not turn your computer or the WR703N off during this process, otherwise you could "brick" the device (ie, render it completely useless).

enabled first via Control Panel (Programs & Features –> Turn Windows Features On Or Off and select the "Telnet Client" check box). Alternatively, use Google to get more detailed instructions.

For Windows XP, Linux and other operating systems, Telnet or a similar terminal program is usually installed by default.

STEP 2: make a note of your PC's current IP address on your LAN (local area network), as well as its default gateway address. In Windows, you can do this by typing **ipconfig /all** and pressing Enter in a command prompt window. The IP address will consist of four 3-digit numbers separated by dots, normally in the form of "192.168.x.x" (eg, 192.168.0.3) or "10.0.x.x".

Note that the one you're looking for is the IPv4 address. In addition, if the PC is connected to the internet, you will also see the IP addresses for the DHCP and DNS servers.

STEP 3: download the new firmware for the WR703N

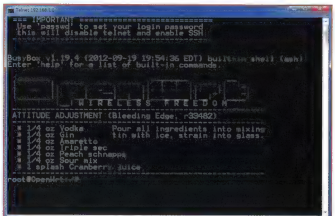


Fig.4: this is what you see when you first connect to the WR703N using telnet after the new firmware has been installed (see Step 9).

router from this website: **http://downloads.openwrt.org/snapshots/trunk/ar71xx/openwrt-ar71xx-generic-tl-wr703n-v1-squashfs-factory.bin**

STEP 4: connect the WR703N to your computer's USB port to power it up. Wait a minute for it to boot, then connect it to your computer via an Ethernet cable.

STEP 5: disable your computer's other network connections (eg, WiFi). The WR703N should now assign a 192.168.1.x IP address to your computer.

STEP 6: open a web browser and enter **http://192.168.1.1** into the address bar. When prompted, log in with the default username and password, both of which are "admin" (without the inverted commas).

STEP 7: you should now see the WR703N's menu system in Chinese language characters. If it's all Greek (or Chinese) to you, don't panic! Just click your mouse on the bottom menu item with a "+" sign next to it (ie, on the lefthand side of the window). This will open up a sub-menu, where you should click on the third item – see Fig.1.

If you picked the correct one, then your browser's address bar may end with the filename **SoftwareUpgradeRpm.htm**. If not, you should see this filename pop up if you hover your mouse over the third item in the sub-menu.

STEP 8: click the button to the right of the white text input box, which will pop up a file "chooser" dialog. Select the firmware file you downloaded in Step 3, then click "OK".

Ditch The Plugpack Supply

The TL-WR703N comes with a plugpack supply with two parallel mains pins plus an adaptor with angled pins. However, this unit doesn't meet Australian standards since there's no finger-guard insulation material on any of the mains pins. In addition, the mains pins are too close to the edges of the plastic housing and the recessed metal contacts inside the back of the pin adaptor are quite exposed.

Our advice is to bin the supplied adaptor and purchase an approved replacement unit from a local supplier. You need to purchase a 5V 1A DC adaptor with a USB output such as the Altronics Cat. M-8889 or the Jaycar Cat.MP-3452.

Of course, if you intend powering the WR703N from a USB port on your computer, then an adaptor is unnecessary.

The next dialog box is just asking you for confirmation, so click the button (it means "OK").

This begins the firmware installation process. You'll see a progress bar moving slowly to the right as the new firmware is installed.

Warning: to avoid problems, do not interrupt this process by turning off the power during this step. Be careful also not to bump any of the cables. If you do, the WR703N could be rendered useless, as you will be unable to get back into it to re-install the software.

STEP 9: assuming the last step worked correctly, your computer will again be assigned an IP address in the same range as before (192.168.1.x). If so, it's now time to set up OpenWRT's web interface and WiFi networking and this has to be done by first running the command **telnet 192.168.1.1** in a command prompt window – see Fig.4.

As a reward for making it this far, you'll be greeted with OpenWRT's welcome screen, which includes a recipe for a strong drink called "Attitude Adjustment" – the makers of OpenWRT show their sense of humour by naming each version after a different cocktail. It's now time to connect the device to the Internet so it can download additional software (eg, the web server).

STEP 10: you must now allocate a fixed IP address for the WR703N so that it is connected to your home or office network (and thence to the internet). The commands below assume that your computer normally has an address starting with "192.168.0." Check the addresses you noted in Step 2 and if they differ, you will need to change these commands to suit (ie, the colour-highlighted parts). The IP address in the "ipaddr" command line below shouldn't conflict with any existing computer on your LAN.

Type these six commands carefully in turn (they must be entered exactly as shown):

(1) uci set network.lan.proto=static
(2) uci set network.lan.ipaddr=192.168.0.123
(3) uci set network.lan.netmask=255.255.255.0
(4) uci set network.lan.gateway=192.168.0.1
(5) uci set network.lan.dns=8.8.8.8
(6) uci commit network

In addition, it's likely that you will already have a DHCP server on the network (eg, in your main router). If so, you will need to instruct the WR703N to ignore DHCP requests as follows:

(1) uci set dhcp.lan.ignore=1
(2) uci commit dhcp

Alternatively, you can disable the DHCP server later on via the web interface, as shown in Fig.7.

STEP 11: reset the WR703N by typing "reboot" and pressing Enter, then unplug its network cable from the PC and plug it into your Internet router instead.

That done, reconnect your PC to the network, either by plugging its LAN cable back into the router or by re-enabling its WiFi connection.

Now wait a minute or so for the WR703N to reboot and then re-connect to it with Telnet, this time using its new address as allocated in Step 10 (ie, 192.168.0.123 if you used our example).

STEP 12: the WR703N should now have Internet access and you can confirm this with a ping test. Enter the command **ping -c 3 google.com** and check that you get responses to the pings.

Each time you want to install extra software, OpenWRT

needs to have its package database updated with the command "opkg update", so run that now.

STEP 13: use the following three commands to set up the web interface and start uhttpd:

(1) opkg install luci

(2) /etc/init.d/uhttpd enable

(3) /etc/init.d/uhttpd start

STEP 14: point your web browser at WR703N's IP address (eg, http://192.168.0.123). This will bring up a web interface where you can see a status report. Now let's configure its wireless networking.

STEP 15: assuming you have a WiFi network (ie, your main router has WiFi), go to Network -> WiFi and click "Scan" which will list the available WiFi networks. Click "Join Network"and fill in the password details (if needed).

Web server set-up

To use the device as a webserver, you need to put files into the "www" directory (or folder). To copy the files across, first you must enable Secure Shell (SSH) support on the WR703N. This involves setting a password for the superuser (root) account. When SSH is enabled, the Telnet interface is automatically disabled.

You will need to download and install an SSH client on your PC. There are several free ones available but we recommend PuTTY (**www.chiark.greenend.org.uk/~sgtatham/putty/**).

Once you have installed PuTTY, type the following command in the Telnet window: **passwd**

Now follow the prompts to enter the new root password. This has to be done twice (once to confirm). With the root password successfully set, close the Telnet window and then connect to the device's IP (same as before) via SSH using PuTTY. Login as root and then enter the password you've just set.

From this point on, the SSH interface behaves much like the Telnet one.

In order to copy files across to the WR703N for its web server, you also need to install SCP (secure copy) client software. We used a freeware program called WinSCP. Refer to the accompanying panel for the instructions on installing this program and copying files across.

Port forwarding

If you want to make the website available from the Internet, you will need to set up "port forwarding" on your main internet router. This is done via its web interface. You need to forward port 80 (http) to the WR703N, using the IP address you assigned to it earlier.

You will need to refer to your router's user manual, as this procedure varies between different brands and models. Fig.10 shows the setup for a Linksys WAG5462.

Note that it will also be necessary to also manually open port 80 in the firewall in some routers.

Other software

To have a look at what other software packages are available with OpenWRT, run the command "opkg list". You can install them using the command "opkg install <packagename>". But don't go installing everything you see, because you'll run out of space very quickly – you can check how much is left using the Linux "df" command.

Remember, the WR703N has only 4MB of internal stor-

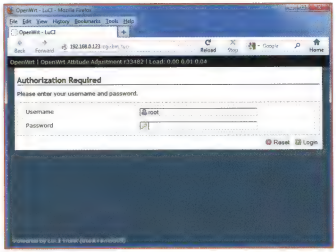


Fig.5: once the web interface has been set up and uhttpd started (Step 13), you can log into the WR703N using a web browser. This screen-grab shows the log-in dialog.

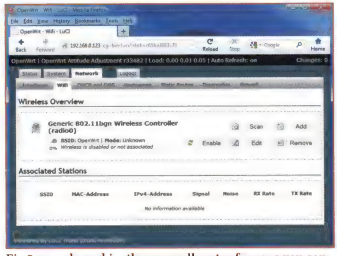


Fig.6: once logged in, there are all sorts of menus you can explore in OpenWRT. This wifi set-up screen allows you to create a new wifi network or join an existing one.

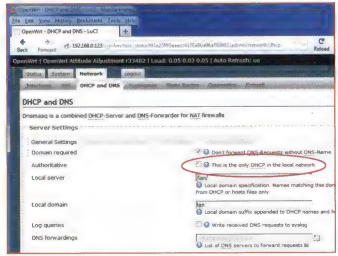


Fig.7: if you wish, you can turn off the DHCP server in the WR703N in the web interface. Just click on the *Network* tab, then on DHCP and DNS and uncheck the "This is the only DHCP in the local network" box (circled).

Installing WinSCP & Copying Files To The WR703N

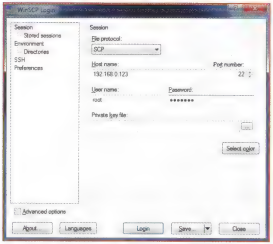


Fig.8: logging into the WR703N router using WinSCP. Choose SCP as the file protocol, then enter the IP address (host name), user name and the set password before clicking the Login button. An option before logging in is to save the profile to make future logins easier.

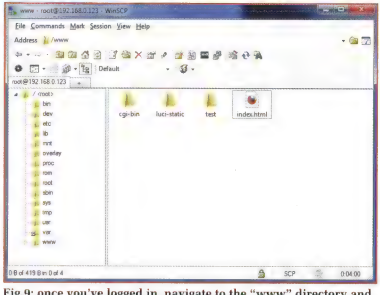


Fig.9: once you've logged in, navigate to the "www" directory and create a new subdirectory called "test". You can then copy an index.htm test file to that folder and view it using a web browser.

THE EASIEST way to copy web files to the WR703N is to use WinSCP. This can be download it from **http://winscp.net/eng/download.php** and installed it on your PC in the usual manner. Choose the Explorer-style interface and simply click through the warning and/or error dialogs that pop up during the installation process.

Once it's installed, start the program and log in to the WR703N router using the SCP protocol – see Fig.8. This will then bring the dialog shown in Fig.9 and you can then easily create and rename folders and copy files into these folders by dragging them across from Windows Explorer.

To test the system, create a directory called ***test*** and copy a file there called ***index.htm***. You should then be able to browse to this file by entering **http://192.168.0.123/test/** in your web browser (note: substitute the WR703N's IP address if it's something other than 192.168.0.123).

age and that has to fit OpenWRT, your software packages AND your website.

More storage

Obviously, the WR703N's internal storage won't be enough for anything but a very small website. But don't worry – you can easily expand on this by plugging a USB flash drive into the unit's single USB port. A multi-gigabyte flash drive costs virtually nothing these days (a few dollars).

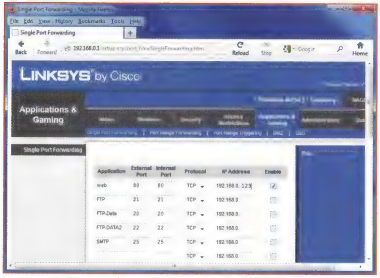


Fig.10: you need to forward port 80 (TCP) on your main internet router if you want to make to WR703N's web server available via the internet.

Once the FAT-formatted flash drive is plugged in, you will need to "mount" it so that the files on the flash drive are accessible. To do this, you will first need to install and enable the necessary packages with these three commands:

(1) opkg install kmod-usb-storage block-mount block-hotplug kmod-fs-vfat kmod-nls-cp437 kmod-nls-iso8859-1

(2) /etc/init.d/fstab enable

(3) /etc/init.d/fstab start

Now after you've plugged in your USB stick, use the administration web interface to go into System and then Mount Points. You should see an entry for "/dev/sda1" – Edit it so that the filesystem type is "vfat" and the mount point is "/www/usb", then use WinSCP to create that folder in the filesystem.

After clicking "Save & Apply", go back and make sure the box is ticked under Enable, then click Save and reboot the WR703N. If you now point your web browser to **http://192.168.0.123/usb** you should see the files on the USB stick.

Coming soon

That's all for this month. As mentioned earlier, a future article will describe how to connect the unit to external hardware such as temperature sensors and relays. SC

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OR SEE THE HANDY ORDER FORM ON P83 OF THIS ISSUE

You thought the last one was dazzling?

SERIOUSLY BRIGHT 10W 20W LED FLOODLIGHT

Last February, we published a DIY 10W LED Floodlight, which has been enormously popular. We said that one was almost blinding – but to paraphrase Croc Dundee, that's not bright. THIS one is BRIGHT!

Design by Branko Justic* Words and music by Ross Tester

SILICON CHIP has just returned from two days at the Sydney Electronex exhibition, where we met a large number of existing readers and also (hopefully!) new readers. On our stand, we displayed several recent – and even a couple of future – projects.

Believe it or not, one project which attracted perhaps the most attention was the 10W LED Floodlight, featured in our February 2012 issue.

This floodlight compared more than favourably with PAR38 incandescent and quartz-halogen floods we all know so well. In fact, few could believe just how bright this was and quite a number wanted the Oatley Electronics phone number so they could order their own kits.

What's this? A 20W?

As luck would have it, waiting for us back in the office was another kit from Oatley Electronics – this time a 20W version of the LED Floodlight.

We quickly assembled this kit and, despite a few wrinkles (which we'll get to shortly) were very impressed with the light output.

To the naked eye (no mean feat because it was far too bright to look at!) it looked much brighter than the 10W LED version, indeed, much brighter than a 150W QI portable floodlight.

We ran some tests using a Jaycar Lux meter on the original 10W LED floodlight, this 20W LED floodlight, the 150W QI floodlight we originally compared the 10W LED to and finally a 500W QI floodlight.

The results appear on the photograph opposite but you'd have to agree that they are pretty impressive for the LEDs.

Of course, the 500W QI does look a lot brighter in the photos – and it is. But remember, we are comparing this to the 20W LED alongside. That's 500 compared to 20 – 25 times the power. It sure ain't 25 times the brightness – both are far too bright to stare into for more than a brief instant.

Just a note of caution, though: we don't know what wavelength that meter is calibrated to. So there could be a "skew" in the figures if it is more sensitive to the bottom (red) end of the spectrum than the top (blue).

The QIs look very yellow indeed compared to the LEDs – and we all know that QIs have a very much "whiter" light than do standard in-

The heart of the project is this 20W LED array. It contains 20 individual LEDs. Like all LEDs, it requires a constant current supply, as described in this article. The light has hit this module "just right" to highlight the "–" and "+" symbols moulded into the plastic – these tell you the polarity of the two metal tabs (as it happens, the top tab, under the finger, is the positive).

candescents.

But as a relative A:B:C:D test, the results are quite telling. And of course, the LED lamps run MUCH cooler than the QIs.

The LED array

As you can see from the photo below, the LED array (or module, if you like) is rather large. The whole thing measures 46 x 53mm (including connection tabs) while the "good bit" (the section which actually produces light) is a rather large 22 x 22mm.

Inside this rectangle are 20 individual SMD LEDs, potted in two rows of ten. Together, they produce a 6000-6500K light at between 1500 and 2500 lumens.

Given that your average 20W fluoro tube produces about 1100 lumens, that's a lot of light from a small area.

The claimed operational range of this 20W LED Flood is from 6V to 30V.

Driving the LED array

In common with all LEDs, it's not possible to simply connect power and away you go! The LEDs do not limit current so will quickly burn out.

And driving a high-power LED is a little different from the garden variety LEDs we have been using for several decades. These basically only require a resistor to keep the LED current within bounds.

The value of this current-limiting resistor can be easily worked out from Ohm's Law – and even then, it's not very critical as long as you don't overdrive the LED.

While you *can* drive a high power LED using a resistor, it's better to arrange a constant-current supply, which is exactly what we've done here.

One advantage of a constant-current supply is that (within reason) it can handle a wide range of input voltages.

Too much power!

One slight problem with the constant current supply included with this kit is that it can supply a bit too much power to the LED – 25W instead of the rated 20W. This will cause the LED to run too hot, thus reducing its life, so there is a slight modification required to reduce power, which we will get to shortly.

The kit includes a 24V, 1A switch-mode power supply – which we will also get to shortly.

The Oatley kit

Everything you need is supplied in the kit, right down to the heatsink compound required to transfer heat from the LED to the case.

Speaking of cases, a glass-fronted floodlamp case is included which has provision on the back for the power supply. It is shown assembled above.

When we say "kit", the controller board is already pre-assembled. This is fortunate, because there are a couple of SMD components on the board – the regulator IC plus a Mosfet used for reverse polarity protection.

Incidentally, if you'd like an explanation as to the how, when, where and why of using a Mosfet for reverse

Comparison shot between (left to right) a 150W QI, 10W LED, 20W LED and 500W QI. This pic really doesn't do justice to the LED floods – they are rather brighter than would appear here. In fact, they're dazzlingly bright!

Some readers may remember the night-time shots of my fishpond comparing the 10W LED to a 150W QI flood. Here's a similar comparison, this time between the 10W LED floodlamp (left) and the 20W LED floodlamp (right). Both were taken from the same place, with the floodlights in the same place, using identical exposures (1/4s @ f/4).

polarity protection, see the "Circuit Notebook" entry in the April 2012 issue (p70). It's much better than using a diode for the same thing.

Construction

The first thing we need to do is make the modification alluded to earlier. This involves removing the 0.33Ω SMD resistor on the right side of the PCB and replacing it with three 1.2Ω resistors in parallel (ie, 0.4Ω).

Removing the SMD resistor is a bit tricky – we used a thin blade to lift one end while we heated the solder join. Having got one end off the board, complete removal is easy.

Obviously, three 1.2Ω resistors (even 1/4W types) in parallel are going to take a bit more space than one SMD resistor. But there is room to place them – twist their leads together first and bend the leads back under to make a "C" shape and tack them to the pads (on the top of the board) vacated by the SMD resistor.

What's the zener for?

There is a second modification required to the PCB if you plan to run the flood from a 24V supply – either the included supply or any other.

The problem here is that the Mosfet used for reverse polarity protection (STM4410A) has a gate-source absolute maximum of 20V so is in dire danger of being popped at 24V.

The way around this dilemma is to fit an 18V zener diode between the aforementioned gate and source.

Fitting this zener is also a bit fiddly – fortunately, three of the pins (1,2 and 3) are connected together as the source on the STM4410A and these make a handy point to solder the anode of the Zener to. The cathode (stripe end) can be soldered to the inner pad of the 10kΩ SMD resistor (again, it is tacked to the top of the PCB).

Note again this mod is ONLY required if you intend to operate the LED Floodlight from a supply greater than 18V (it is quite happy to run at 12V, by the way, with full brilliance).

DC power supplies

Here's where we struck a snag – and we thought we'd better mention it before final assembly as it might make a difference to what you do.

We mentioned earlier that Oatley Electronics include a Chinese-made 24V, 1A switchmode power supply with the kit, which should be more than adequate to drive the power supply and LED array. (20W/24V=830mA; add a bit for losses and it should still be well under 1A).

But the power supply couldn't cope – it was as if it was continually starting and shutting down under overload. The effect was that it "strobed" the LED array – fine if you're looking for a party light but not very practical for a floodlight! Oatley Electronics told us they had received occasional reports of this happening but equally, large numbers where it didn't.

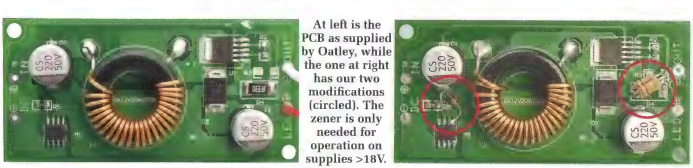
So we tried our prototype with three other (identical) power supplies and the same thing happened.

Switching over to a 12V, 3A supply solved the problem completely – obviously the floodlight drew more current (20W/12V=1.7A) but that was no drama for a 3A supply.

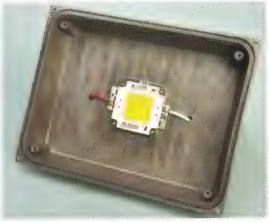
So if your floodlight strobes like ours did, you're going to need a different power supply. The circuit diagram says a DC input from 6 to 30V; bear in mind that the lower the supply voltage, the higher the power supply current. At 6V, you're going to need a supply capable of nearly 4A; at 30V, the supply can be less than 1A.

Assembly

Now that we have the fiddly bits



At left is the PCB as supplied by Oatley, while the one at right has our two modifications (circled). The zener is only needed for operation on supplies >18V.



At left you can clearly see the four tapped mounting holes for the LED array. The two outer holes are for power wire entry. At right, the LED array has been mounted (with heatsink compound underneath) and the two power wires (red and white) soldered to their respective tabs. Note the red and black marks we put on to show which was which!

out of the way, it's time to put it all together.

First, you need to identify the "+" and "-" terminals of the LED. It's not easy!

Unless your eyesight is in the macroscopic class, you'll probably need a magnifying glass. You're looking for a + and – symbol moulded into the white plastic "case" which surrounds the LED array itself.

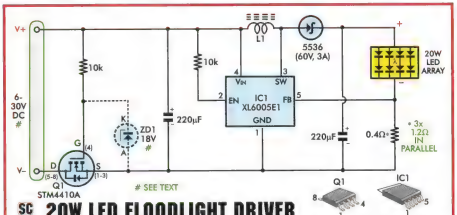
Once you've found them you can then identify which of the two metal tabs is positive and which is negative. (Our photo shows which is which).

We kept losing the symbols (especially under normal office light) so in the end put a spot of red marker pen against the + symbol. It helped!

On the inside of the main (large) case, you'll find six holes. The four smaller holes form a square and these are used to mount the LED module. First, though, apply a good coat of heatsink compound (supplied in the kit) to the rear of the LED array and smooth it out.

Mount the LED array with four of the small countersunk-head metal screws – the holes are already tapped. Any heatsink compound that oozes out the edges should be removed with a cloth.

The other two holes will be used to pass the power cables through shortly.



Here's the circuit of the 20W LED driver, published more for interest's sake than anything else because it comes pre-assembled on a small PCB. All you need do is change a resistor value and, if needed, add a zener diode.

Wiring

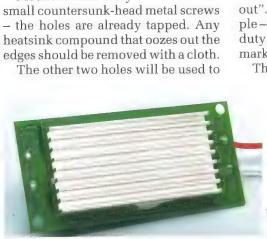
You need to connect the wiring to the PCB before mounting it in its case. The case containing the power supply PCB is actually separate from the main case and is attached to it via four screws. In fact, it is the lid which is attached to the case and the case body screws down onto the lid.

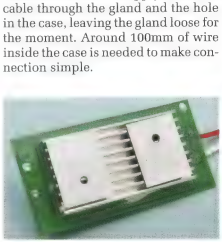
There are four wires required to connect it – two "DC in" and two "LED out". The two LED out wires are simple – just solder some relatively heavy duty pickup wire to the two terminals marked LED OUT + and –.

These wires pass through the two holes into the main case and are soldered direct to the metal tabs on the end of the LED array – after once again checking you have identified the + and – tabs.

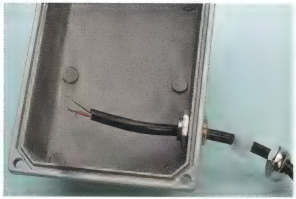
The DC in wires are simple enough, a positive and a negative, but depend on whether you are going to use the power supply in the kit or some other supply.

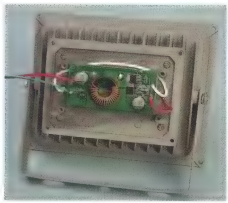
Either way, a cable gland is supplied in the kit which suits the round cable from the DC supply. Pass the cable through the gland and the hole in the case, leaving the gland loose for the moment. Around 100mm of wire inside the case is needed to make connection simple.





The power supply PCB has a heatsink attached to the back which needs to be in intimate contact with the case. Rather than drill and tap holes, we used a pair of TO-3P mounting pads which are self-adhesive both sides and therefore keep the board in place, while transferring any heat to the case.





There's a pre-drilled hole in the case to accept the cable gland (supplied). It ensures that the box is watertight and won't provide a warm, happy home to ants and insects. At right is the PCB mounted in the case lid attached to the main lamp body. There's no screws on the PCB: it's held in place by a couple of self-adhesive thermal transfer pads.

It's probably easiest to cut any plug off the DC supply and wire direct to the PCB but you may need to identify the + and – wires from the supply; in our case there were four wires, red, black, green and white.

The positive lead was red, as expected, but the negative lead was the white, not the black. If you solder direct, make sure you insulate the ends of the other two wires, as well as the red and white, to prevent shorts.

The alternative is to leave the plug on the power supply and drill a hole in the side of the case and fix a panel-mounting socket to the case, wired to the PCB. This will make the floodlight a lot more portable, if that's your want!

Mounting the power supply

The power supply PCB has two mounting holes but we cheated a bit and glued it in place with self-adhesive thermal pads intended for TO-3P transistors. These are more than capable of sticking to the heatsink fins and also to the case itself. (These are not supplied in the Oatley kit).

For convenience, we mounted the PCB on the case lid, with the wires going directly from there through to the LED.

Solder the power leads to the tabs on the LED array, again making absolutely sure which way around they go. With the + and – symbols towards the bottom, the + tab is at the top and the – tab is on the bottom. Pull any excess wire back into the power supply case.

Putting it together

From here, it's simply a matter of screwing together the various bits – screws are supplied.

The reflector mounts inside the lamp assembly so that it sits on the outside of the LED array; the glass front slots into its frame and, via a gasket (supplied) screws to the outer rim of the floodlamp.

On the back, the PCB case back screws onto its lid which should have come already connected to the floodlamp.

The U-bracket, used for mounting, should also be already connected to the floodlamp but you may need to tighten its screws once in position. In fact, you'll probably have to remove it to facilitate mounting.

Choose a mounting position (say) under an eave or overhang. There's not much heat given out so that's not normally a worry. SC

Where From, How Much?

The 20W LED Floodlight kit was designed by Oatley Electronics, who retain the copyright.

It is available as a kit (K329), for $40.00 inc. GST from Oatley Electronics, PO Box 89, Oatley NSW 2223.

This kit includes all components (PCB is pre-assmbled) and the case as shown in this article. A 24V 1A switch-mode supply is also included.

If operating from a supply higher than 18V, you will also need an 18V zener diode, as described in the text.

*Branko Justic is the owner of Oatley Electronics.

This 6000-count true RMS multimeter has a built-in non-contact voltage detector, low impedance voltage measurement mode and the option of a Bluetooth communication module for wireless data logging.

Review by NICHOLAS VINEN

Agilent U1233A True RMS DMM with U1117A Bluetooth Adaptor

The Agilent U1233A Cat III 600V digital multimeter can measure AC and DC volts, frequency, resistance, capacitance, temperature (with a thermocouple), AC and DC amps and microamps and current frequency. It also has diode and continuity test (with a beeper), a display backlight and a built-in LED torch.

Additional modes include relative measurements, max/min measurements, auto or manual ranging, reading hold/auto-hold and battery state display.

There are some things we particularly like about this multimeter. One is that there is no need to change the connections when you switch between amps and microamps modes as there is a single current measurement terminal.

Also, the fact that it goes up to 60MΩ in resistance mode is good as many meters will only read to 10MΩ. The bar graph (below the numeric read-out) makes it easier to interpret rapidly changing readings.

We also like the probes that are supplied. Not only are they good quality but the probe ends pull off to reveal insulated banana plugs, making it easy to wire the meter up to other test equipment with banana sockets, such as bench supplies.

The selector switch is chunky and is logically laid out; they haven't packed a gazillion different modes into one position. The built-in non-contact voltage detector and torch are nice touches.

Also, unlike some meters, it uses four AAA cells for power rather than a 9V battery. 9V batteries are pretty expensive and don't usually last that long (especially if you're going to use the LED torch a lot).

Features

The non-contact voltage detector is called "Vsense" and is located at the top of the meter. When you enable this mode and place that end near a live mains conductor (eg, a wall power point), you get a beeping sound and a red LED lights up. You can set the sensitivity to two levels, high and low.

The low-impedance voltage measurement mode is designed to eliminate false readings caused by inductive and capacitive coupling into the wires or circuit you are measuring.

This is especially useful in an environment with a lot of mains cables but even in a standard office setting, you can easily get false readings from EMI and hum fields.

One interesting feature is the ability to invert the sense of the continuity beeper so that it will beep on an open circuit rather than a short circuit. You can also change the pitch of the beeper.

The resolution when measuring capacitance is 1nF, which is higher than we prefer but on the other hand, it will read capacitances over 10,000μF which is pretty good, with a test time of around 10s. We like that it shows you when it is charging and discharging the capacitor under test. Also, the maximum frequency reading is 100kHz which is a little low (some meters will go to 10MHz or more).

The basic accuracy of the unit is of the order of ±0.5-1% for most readings with ±2% for capacitance readings, ±1.5% for AC current and ±1.0% for DC current (not including additional lowest digit variation, which is specified in the data sheet).

Input impedance for voltage readings is 10MΩ in the normal mode and 3kΩ in the low-impedance mode. The resolution on the lowest range in each case is 0.1mV (volts mode), 0.01μA (microamps mode), 1mA (amps mode), 0.1Ω (resistance mode), 0.001V (diode test/forward voltage) and 0.1°C (thermocouple temperature).

Shown larger than life size for clarity, the U1177A Bluetooth adaptor simply clips onto the back of the meter. It has its own battery and on/off switch and communicates with the meter through an optical interface. At the top of the meter, you can see the large lens for the inbuilt LED torch.

The test leads supplied with the Agilent U1233A "feel" much better and more robust than those supplied with most multimeters, while the probes themselves come apart (as shown here) so they can accept other fittings.

Bluetooth data logger

While this is a nice multimeter, the real reason for us getting a unit to review is the U1177A Bluetooth add-on which clips onto the back. This has its own battery and communicates with the meter via an optical connection.

With this add-on, connecting to the meter using Bluetooth is easy.

All we had to do in Windows 7 was switch the dongle to "Setup" mode, tell the operating system to add a new hardware device, select the Agilent item which popped up and add the pairing code, which is stated in the provided set-up guide. Then, when the dongle is switched on and in range, the meter appears as a pair of serial ports on the computer.

You can then connect to the serial port via a terminal program and read out the value currently displayed on the meter's screen.

Agilent provide free software, called "Agilent GUI Data Logger", which can be used to log and graph this data at a rate of up to 1Hz. The software can also control some aspects of the meter, such as turning the backlight on and off or changing the data range.

While we wouldn't call this a stellar piece of software, it works OK and we were able to log data from the multimeter into a spreadsheet and a graph. Sufficient information is provided with the U1177A that should you wish to, you can write your own software to interface with it.

Note that the U1177A adaptor will work with virtually any Agilent multimeter that has the infrared interface.That includes the majority made in the last few years.

By the way, if your computer doesn't have Bluetooth, you can also get the optional Optical/USB adaptor cable (U1173A) or just buy a USB-Bluetooth adaptor.

Conclusion and special offer

Currently, Trio Smartcal are offering a free U1177A IR to Bluetooth DMM Adaptor with the purchase of a range of DMMs including the U1230 series. This offer is valid until the end of February 2013.

The U1233A True RMS DMM is $164.95 (+GST). The slightly less capable U1231A is $98.95 (+GST) while the U1232A is $141.90 (+GST).

We think that's a pretty good deal, considering the U1233A's provenance and its range of features, especially when combined with the Bluetooth adaptor. It's a good basic True RMS DMM with some nice added features and it should provide years of faithful service.

For enquiries or purchases, contact Trio on 1300 853 407 or visit http://triosmartcal.com.au

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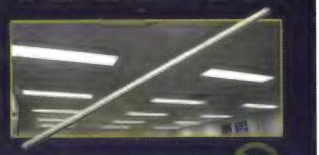

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CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.

Jack Holliday is this month's winner of a $150 gift voucher from Hare & Forbes

Programmable RF remote timer/switch

Do you have remotely located devices that you would like to turn on for a time that can be programmed independently for each device, or perhaps just be able to toggle the devices on and off at will? These two circuits do all this with the convenience of a remote control.

The master circuit uses a Mini Maximite as an embedded controller. Communication with the master controller is via a Sony-compatible IR remote control. You can either use a genuine Sony remote or a universal remote programmed with a Sony TV code.

The timing period for up to 10 slaves can be individually programmed from the master which uses a 10-element LED array (LEDs 1-10) to identify which slave (1-10) the master is interacting with at a given time. An additional green LED acts as a "ready" indicator to show that the master is waiting for input.

Programming information from the Sony remote is received by the IR receiver and passed on to pin 8 of the MiniMaximite where it is decoded. The decoding of the Sony remote uses a special technique devised for this purpose. This is the reason for connecting the SOUND output to pin 11. You may wish to refer to the Circuit Notebook pages of the October 2012 issue for more details of this technique.

Once all the necessary information has been received by the MiniMaximite, the appropriate instructions are encoded and sent via its COM2 port to a Dorji RF transceiver.

Each slave will receive this encoded information, again via a Dorji transceiver. This information is passed to a PICAXE08M2 microcontroller which checks the transmission for the presence of its own unique identifying code. If the slave detects its own identifying code it will respond by performing the instructions that have been transmitted along with the code.

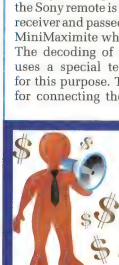
The slave also sends an acknowledge signal back to the master. If the master does not receive this acknowledge signal it will rapidly flash the LED corresponding to the slave five times. In this way, you will know there is a communication problem between master and slave (perhaps the slave is not turned on etc) and you can take steps to rectify the problem.

According to the instructions received, the slave can turn Q1 on or off via pin 3 of the PICAXE and so relay RLY1 in turn switches mains power to the switched GPO outlet. Switch S1 can be used to turn the slave on or off as required or force its output to turn on.

The code for slave1 needs to be altered for use with other slaves. For slave2, for example, in lines 17, 18, 28, 29, 43, 61 and 69, every occurrence of "A1" needs to change to "A2" and "1" needs to be changed to "2". A corresponding change is required for all higher numbered slaves. The line numbers referred to above are those which appear on the left of the screen when editing the slave1 program using the Picaxe Programming Editor in "colour syntax" mode.

When the master is first switched on it enters its standby mode, with green LED11 illuminated. LED11 is on whenever the master is waiting for input. The first key press on the Sony remote should be the slave number you wish to program (slave3, say). When this is done, one of LEDs 1-10 will illuminate to indicate a successful transmission. In this example, LED 3 will light and green LED11 will also be lit. (For slave 10 use the "0" button on the remote. This is a quirk of the Sony remote control codes).

continued on page 76



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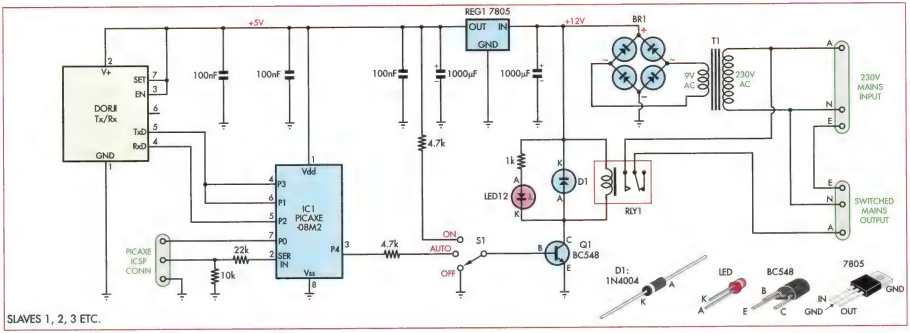
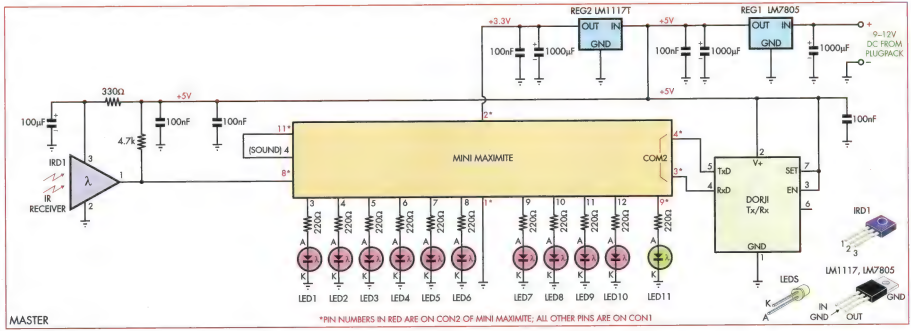

REG1 7805
OUT IN
GND
+5V
+12V
BR1
T1
9V AC
230V AC
230V MAINS INPUT
SWITCHED MAINS OUTPUT
DORJI Tx/Rx
V+
SET
EN
TxD
RxD
GND
100nF
1000µF
4.7k
1k
LED12
D1
RLY1
IC1 PICAXE -08M2
Vdd
P3
P1
P2
P0
P4
SER IN
Vss
PICAXE ICSP CONN
22k
10k
ON
AUTO
OFF
S1
Q1 BC548
D1: 1N4004
LED
BC548
7805
IN
OUT
SLAVES 1, 2, 3 ETC.


REG2 LM1117T
REG1 LM7805
+3.3V
+5V
9–12V DC FROM PLUGPACK
330Ω
100µF
100nF
1000µF
4.7k
IRD1
IR RECEIVER
(SOUND)
MINI MAXIMITE
COM2
DORJI Tx/Rx
TxD
RxD
LED1
LED2
LED3
LED4
LED5
LED6
LED7
LED8
LED9
LED10
LED11
LED5
LM1117, LM7805
*PIN NUMBERS IN RED ARE ON CON2 OF MINI MAXIMITE; ALL OTHER PINS ARE ON CON1
MASTER

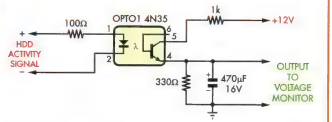
Hard drive activity indicator

This circuit can be added to the Vehicle Multi-Voltage Monitor Project from the May 2006 issue of SILICON CHIP, allowing it to act as a hard disk drive activity level meter. The harder the computer's drive(s) are working (ie, the greater their active duty cycle), the more LEDs will be lit on the Multi-Voltage Monitor.

An optocoupler (OPTO1) is used to isolate the hard disk drive activity signal and couple it to the Vehicle Multi-Voltage monitor. This activity signal is taken from the appropriate pair of pins on the PC motherboard (normally labelled "HDD").

When the HDD activity signal is present, the output of OPTO1 turns on and charges a 470µF capacitor via a 1kΩ resistor from +12V. When the signal turns off, so does the optocoupler output and this capacitor then discharges via its parallel 330Ω resistor. Thus, the charge across the capacitor is roughly proportional to the duty cycle of the activity signal. The 1kΩ and 330Ω resistors form a divider which limits the capacitor voltage to 3V at 100% duty cycle.

The only adjustments required on the Voltage Monitor



are to adjust VR1 fully clockwise and VR2 fully anti-clockwise. VR3 can be adjusted for brightness. Links 1 and 2 are left out and Link 4 is inserted.

For best visual effect, the Voltage Monitor should be run in bargraph mode. Cut-outs can be made in a spare drive bay blanking plate for the 10 LEDs and the LDR.

12V power for the circuit (as well as the Voltage Monitor) can be obtained from a spare hard disk drive power lead from the computer's power supply, coupled using a female Molex plug. These are available from Jaycar and Altronics or you can simply cut a spare power Y-cable or adaptor cable and solder to the leads.

Note that virtually any standard type of optocoupler may be substituted for the 4N25.

John Rigon,
Werribee, Vic. ($45)

Programmable RF remote timer/switch: continued from page 74

The next button to press on the remote is a number from 1-4, indicating what function you want to perform on slave3. Button 1 is for a PROGRAMMED TIMER function, buttons 2 and 3 are simple toggle ON and OFF functions respectively, and button 4 is a CANCEL TIMER function.

Suppose we have selected the programmed timer function by pressing button 1. The LED display will clear and LED11 will be lit, indicating that the master is ready to receive the desired time that we want slave3 to stay on for. The time can now be entered in HHMMSS format. Any time up to 999999 can be entered, so the timer can accurately have ON times for up to 100 hours.

As you do so, LEDs 1-6 of the display will progressively light in confirmation until all six digits have been entered. At this point the timing information is transmitted to slave3 which will immediately apply mains power to its switched GPO for the time interval that has been programmed in. Meanwhile the master will revert to its standby mode, waiting to send programming information to any of the slaves.

If for some reason you do not wish slave3 to continue timing and want to abort the timing process, you would press 3 (to select slave3) followed by 4, the CANCEL TIMER function.

To make slave3 act as a simple toggle switch, press 3 (to select slave3) then press 2. LED3 will light, indicating slave3 is ON and the master then returns to standby. Slave3 will remain on until the button combination of 3 followed by 3 is executed, upon which slave3 will be OFF, LED3 will extinguish, and the master once more reverts to standby.

Note that while in PROGRAMMED TIMER mode the slave is busy keeping a check on elapsed time and so cannot respond to any of the toggle instructions described in the previous paragraph. The only command the slave can respond to in this mode is the CANCEL TIMER instruction.

So you can't use the toggle OFF function to cancel a PROGRAMMED TIMER condition – instead, you must use the CANCEL TIMER sequence.

Jack Holliday,
Nathan, Qld.

Note: the software, *slave1max.bas* and *switchsc.bas*, can be downloaded from the SILICON CHIP website.

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GSM alarm system uses hard disk as a motion sensor

This alarm system will call a mobile phone when it senses motion. It is built into the box of a computer hard disk drive (HDD) which is used as a sensitive transducer.

Even the slightest motion of the rotor of the HDD produces a voltage in the stator coils and this is fed to an LM311 comparator (IC1). It drives LED1 which flashes when any motion is detected, as IC1's output is pulled low. IC1 also drives gate IC2a which inverts the signal and turns on transistor Q1 which charges a 47µF capacitor.

This enables the oscillator comprising gates IC2b & IC2c which then clock pin 14 of IC3, a 4017 counter. Its outputs are mixed via diodes D1-D4 to drive transistors Q2 & Q3. These transistors each drive optocouplers which have their outputs wired across the "cancel" (end call) and "call" buttons of a mobile phone.

The first two high outputs from IC3 are fed via diodes to turn on transistor Q2, and it presses the "cancel" button via optocoupler OPTO1. This is necessary in order to reset all random and non-random calls, as well as incoming SMS. Then, in the same way, transistor Q3 presses the "call" button. Thus a call to the last dialled number will be made after about 5s.

Having counted to 10 the counter stops because pin 11 goes high and resets it via pin 13. After a period of about 15s, the 47µF capacitor has discharged and the circuit is ready for another alarm call. The first alarm pulse (any motion of the sensor) from the emitter of Q1 is fed via a 1µF capacitor to reset pin 15 of IC3 and a new cycle begins.

Any GSM system will be suitable. Carefully solder leads to the contacts of the "call" and "cancel" buttons and to the battery's pins (+ and -) for powering the alarm system itself. The current consumption from the battery in standby is typically around 1-3mA.

Alexey Uskov,
Vladivostok. Russia. ($45)

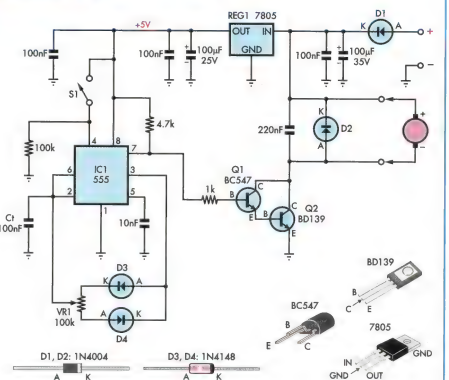
Fixed-frequency PWM motor speed control

This circuit is intended for varying the speed of any low-voltage DC motor, including various types of DC computer type fans. It can control the duty cycle to between less than 5% and more than 99.5%, while the frequency remains constant.

It is based on a 555 (IC1) configured as a basic astable timer but with a variation whereby the capacitor (Ct) at pins 2 & 6 is charged and discharged from the output at pin 3. The duty cycle depends on the position of the potentiometer (VR1).

On power up, the voltage across Ct is less than the trigger voltage on pin 2. The timer is then triggered. The output pin of the timer then goes high. This turns off the discharge (pin 7) and brings the output (pin 3) high, allowing Ct to charge via D3 and VR1.

When capacitor Ct charges to the upper threshold voltage, the flip-flop inside IC1 is reset, causing the output to go low. Ct then discharges through potentiometer VR1 and diode D4 until the lower threshold level is reached and the complete cycle is then repeated.



Pin 4 of the device is held low via a 100kΩ resistor and this normally disables the circuit. When switch S1 is on, it pulls 4 high and the oscillator can run. Pin 7 is used as the output and it drives Darlington pair Q1 & Q2 which in turn drive the motor. Note that the Darlington saturation voltage reduces the maximum motor speed somewhat.

Michael Azzopardi, Deer Park, Vic. ($40)

Radio, Television & Hobbies: the COMPLETE archive on DVD

This remarkable collection of PDFs ***covers every issue*** of R & H, as it was known from the beginning (April 1939 – price sixpence!) right through to the final edition of R, TV & H in March 1965, before it disappeared forever with the change of name to EA. Complete and in one handy DVD, every article and every issue is covered.

If you're an old timer (or even young timer!) into vintage radio, it doesn't get much more vintage than this. This archive gives an extraordinary insight into the amazing breakthroughs made in radio and electronics technology following the war years.

And speaking of the war years, R & H had some of the best propaganda imaginable!

Even if you're just an electronics dabbler, there's something here to interest you.

Please note: this archive is in PDF format on DVD for PC. Your computer will need a DVD-ROM or DVD-recorder (not a CD!) and Acrobat Reader 6 or above (free download) to enable you to view this archive. This DVD is NOT playable through a standard A/V-type DVD player.

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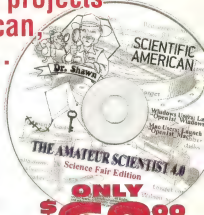

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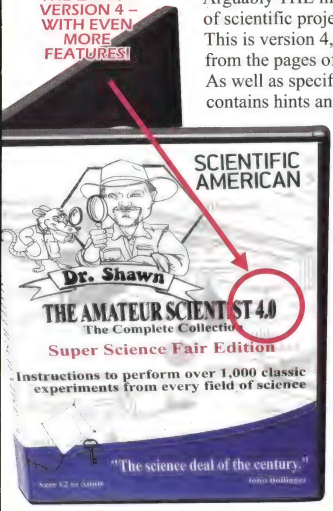

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PRODUCT SHOWCASE

$169 Atten F2700-C 2.7GHz Frequency Counter from Jaycar

With so much happening in the 2.4GHz band these days – Wifi, Xbee, comms and much more – you need a frequency counter that will "go the distance".

That's where this new bench Frequency Counter from Jaycar Electronics will really prove its worth.

It has two channels, one covering from 10Hz to 10MHz direct and 10MHz to 100MHz by proportion; the second measures 100MHz to 2.7GHz, again by proportion.

It features eight LED digits and has four functions: frequency, period, totalling and self-checking.

On the 10MHz range (channel 1), sensitivity is 70mV up to 8MHz and 30mV from 8-10MHz. On the 100MHz range sensitivity is 30mV from 10-100MHz. Input impedance is 1MΩ (less than 35pF). Channel 2 offers 30mV sensitivity to 2.4GHz and 75mV 2.4-2.7GHz, with input impedance of 50Ω.

Measuring 82 x 207 x 215mm (wxhxd) it is mains operated (IEC cable supplied) so is ideal for the service bench or laboratory.

Retail price is just $169.00 (cat QT2202) and it's available from all Jaycar stores or website.

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Graphene: microscopically thin layer of corrosion protection

A coating so thin it's invisible to the human eye has been shown to make copper nearly 100 times more resistant to corrosion, creating tremendous potential for metal protection even in harsh environments.

It's called "Graphene", a microscopically thin layer of carbon atoms. It is already in use in such things as smartphone screens and is attracting research attention for its possibilities as a means of increasing metal's resistance to corrosion. It has excellent mechanical properties and great strength.

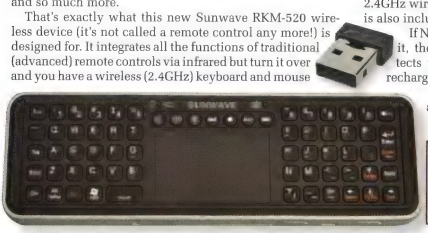
In a paper published in the September issue of Carbon, researchers from Monash University (Melbourne) and Rice University in the USA say their findings could mean paradigm changes in the development of anti-corrosion coatings using extremely thin graphene films.

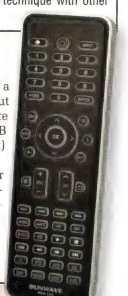
The polymer coatings that are often used on metals can be scratched, compromising their protective ability but the invisible layer of graphene – although it changes neither the feel nor the appearance of the metal – is much harder to damage.

The researchers applied the graphene to copper at temperatures between 800 and 900°, using a technique known as chemical vapour deposition, and tested it in saline water.

Initial experiments were confined to copper but research is already under way on using the same technique with other metals.

Altronics "Sunwave" wireless remote controls for smart TVs etc





If you own a "smart" TV or even a computer or home entertainment system, a traditional remote control offering channel changing, volume and a power switch simply doesn't cut it.

There are so many extra things you need to control, not to mention the ability to input text (eg website addresses) and so much more.

That's exactly what this new Sunwave RKM-520 wireless device (it's not called a remote control any more!) is designed for. It integrates all the functions of traditional (advanced) remote controls via infrared but turn it over and you have a wireless (2.4GHz) keyboard and mouse (in the form of a touch pad).

Admittedly, you're never going to be a touch typist on its QWERTY keyboard but it (and the touchpad) gives you complete wireless communication. A tiny USB 2.4GHz wireless receiver (pictured left) is also included in the box.

If NiMH cells are used to power it, the device automatically detects their use and they can be recharged via the USB socket.

It's priced at $139, available from all Altronics outlets (Cat A1004).

Contact:
Altronic Distributors Pty Ltd
PO Box 8350, Perth Busn Centre, WA 6849
Tel: 1300 780 999 **Fax:** 1300 790 999
Website: www.altronics.com.au

DORJI appoints Wiltronics Australian distributor

Shenzen (China)-based Dorji Applied Technologies, has appointed Wiltronics Research Pty Ltd as its Australian Distributor for their innovative range of RF modules.

The products include simple ASK transmitter and receiver modules through to a range of GFSK transceiver modules.

Wiltronics, based in Ballarat, Victoria, distributes a large range electronic components & equipment and was also recently appointed as the Australian PICAXE Distributor. Wiltronics operates under an ISO9000 accredited Quality Management System and is focused on a high level of customer service.

DORJI
Applied Technologies

The company's extensive range of products, including a large range of DORJI modules, is all available online via their website or via phone.

Contact:
Wiltronics Research Pty Ltd
U/4 Cnr Ring Rd & Sturt St, Ballarat Vic 3350
Tel: (03) 5334 2513 **Fax:** (03) 5334 1845
Website: www.wiltronics.com.au

Training board for PIC programming tutorials

Gooligum Electronics has released a training board specifically designed to complement its well-regarded PIC programming tutorials.

The tutorials use C and assembler to introduce the baseline and mid-range PIC families, starting with easy-to-understand baseline devices, and moving on to topics such as displaying analog signals on multiplexed 7-segment displays, using mid-range PICs.

The training board comes with all 40+ lessons on CD and all the components, including PICs, needed for each example. It can also be used as a general development board for 6-14 pin PICs.

It costs $89 assembled, or is available as a kit for $69.

Contact:
Gooligum Electronics
32 Mistletoe Ave, Macquarie Fields NSW 2564
Website: www.gooligum.com.au

New Flowcode release from Matrix

Matrix has released the dsPIC version of its popular Flowcode software, ideal for those who want more processing power.

Flowcode 5 is one of the world's most advanced graphical programming languages for microcontrollers, allowing those with little experience to create complex electronic and robotic systems.

Flowcode uses macros to facilitate the control of complex devices like 7-segment displays, motor controllers and LCD displays. It can be used with many microcontroller development hardware solutions and is used in many schools, colleges and universities worldwide in the teaching of technology, science, electronics, automotive and so on.

To try Flowcode for free, or for further information visit the Matrix Multimedia website.

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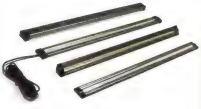
Ocean Controls' LED Cabinet Lights



These flat strip lights use small LEDs to produce an even illumination with low power consumption. The included low-profile mounting clips allow installation in tight spaces for workspace illumination, bookcase lighting, architectural lighting or product showcases.

The flat strip has a profile only 8mm thick and 33mm wide and is available in 300, 500 and 1000mm lengths. Using connectors or corner pieces, the lights can be easily daisy-chained together to produce an extra long light or a square or rectangular shaped light.

A 12VDC or 24VDC plug pack (not included) can be used to power the lights. The low-voltage supply means they are ideal for automotive, caravan and camping applications. These flat strips are compatible with our dimmer, inline switch, PIR sensor and four-way splitter.

Contact:
Ocean Controls
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Tel: (03) 9782 5882 **Fax:** (03) 9782 5517
Website: www.oceancontrols.com.au

Tiny SPU03 DC-DC Converters from ADM

ADM Instrument Engineering have available a range of tiny (19.6x7.5x10.2mm) DC-DC converters from Mean Well.

The SPU03 series includes outputs of 5V/600mA, 12V/250mA and 15V/200mA, with inputs of 5, 12 and 24V (nominal). They feature 3000VDC isolation and built-in EMI filters. They're short-circuit proof and come in a single in-line package with just four connections – $\pm V_{in}$ and $\pm V_{out}$. Cooling is by free-air convection and they come with a 100% full-load burn-in test.

ADM is a well established, Australian owned company providing a broad range of industrial instrumentation, transducers, sensors, radiation services & detection equipment. They have been operating in Melbourne for 25 years providing instruments, free technical advice and specifications. *sc*

Contact:
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Website: www.admtech.com.au

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- **Even if stock runs out (eg, for high demand), in most cases there will be no longer than a two-week wait.**
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Vintage Radio

By Rodney Champness, VK3UG

The HMV A13B 4-Valve Twin-Chassis Mantel

Produced by HMV during the early 1950s, the A13B 4-valve mantel receiver was small in size but big in performance. It's also an easy set to work on and a simple modification to the oscillator circuit makes it work even better.

I FIRST SAW one of these receivers at my grandparents' home in the early 1950s. I'm not sure why I was so intrigued with the set; maybe it was because it was so small compared to other radios I was familiar with at the time (mainly large vibrator-powered receivers that ran off batteries). Or perhaps I was impressed by the performance delivered by such a small set.

Of course, by modern standards, it isn't all that small. However, at the time, it was the smallest I had seen and my grandparents' set was even housed in a brown Bakelite cabinet, just like the A13B receiver featured here.

A little history

HMV has always built interesting receivers, both from a technical viewpoint and in terms of appearance. The cabinet of this receiver is much smaller than other 4-valve superhet receivers. It features rounded edges and a central dial scale which looks quite attractive, although it is relatively small. The loudspeaker is located to the left and is partly behind the dial scale.

The cabinet has four large holes towards the top of the rear panel, designed to accept four fingers so that the set can be easily lifted and moved from one location to another (after first disconnecting the antenna and unplugging the set from the mains). The antenna supplied with the set was around 6-7m long and this was typically draped along a picture rail or run along the skirting board in the room.

As an aside, radio receivers of this era were often supplied with a short-wire antenna. This could be used in good signal areas instead of the set being connected to a large, outside antenna. Of course, that was before ferrite-rod antennas came into common use.

In practice, most people soon abandoned the idea of shifting such sets from room to room, since relocating the antenna each time was a nuisance. The advent of the ferrite-rod antenna made shifting valve sets easier but it wasn't until transistor receivers arrived that sets became truly portable.

The advent of transistor receivers also eventually made it possible for households to afford multiple sets. By contrast, at the time the HMV A13B was produced, receivers were expensive and the average household could only afford one receiver.

Circuit details

Fig.1 shows the circuit details of the HMV A13B. It's a 4-valve superhet design (broadcast band only) but its performance matches that of many 5-valve receivers due to the fact that its IF (intermediate frequency) amplifier valve also acts as the first audio stage. This particular circuit technique is called "reflexing" and was common in Australia from the 1930s to the mid 1950s. However, it was not used as much in other countries.

The antenna input circuit (top, left)

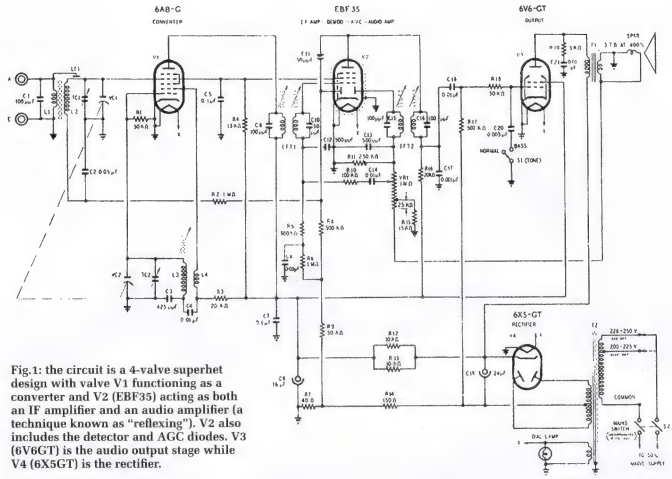
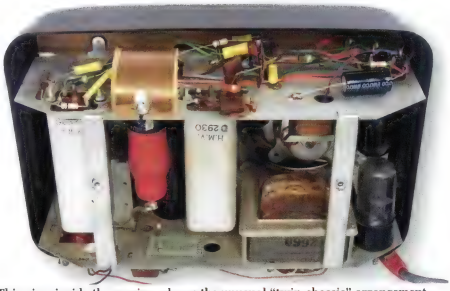


Fig.1: the circuit is a 4-valve superhet design with valve V1 functioning as a converter and V2 (EBF35) acting as both an IF amplifier and an audio amplifier (a technique known as "reflexing"). V2 also includes the detector and AGC diodes. V3 (6V6GT) is the audio output stage while V4 (6X5GT) is the rectifier.

was designed to extract the maximum possible signal from a relatively short antenna. As shown, the antenna input coil L1 is tuned using parallel capacitor C1, the resonant frequency of this combination being just below the bottom end of the broadcast band. By doing this, the maximum possible signal is extracted from the antenna at the low-frequency end of the band and this signal is inductively coupled to coil L2.

At the high-frequency end of the band, capacitor LC1 couples the antenna signal direct to L2. Either way, the signal is fed into a secondary tuned circuit comprising L2, TC1, VC1 & C2. C2 is the AGC bypass capacitor and although it's included in the tuned circuit, it has little effect on its tuning.

The signal from the antenna tuned circuit is fed to the signal grid of V1, a 6A8G converter valve. The local oscillator is a little different from normal in that it uses "padder feedback", achieved by connecting bypass capacitor C4 to the tuned oscillator winding instead of to chassis (earth).

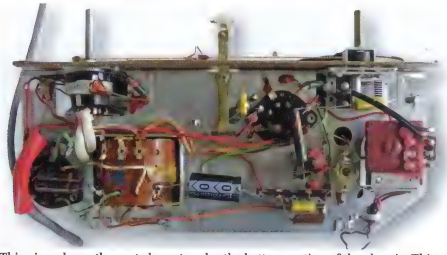


This view inside the receiver shows the unusual "twin-chassis" arrangement, with the parts mounted mainly on the two horizontal sections.

This ensures that the oscillator operates reliably at the low-frequency end of the tuning range.

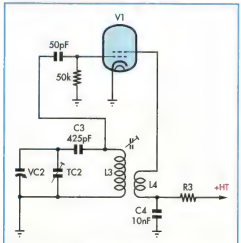
However, I don't particularly like the design of this circuit. The circuit used in the A13B was slavishly followed by many manufacturers but other manufacturers used the circuit shown in Fig.2. This is a more dependable circuit that will oscillate

The top section of the chassis supports valves V2 & V3 (EBF35 & 6V6-GT) plus the two IF transformers. Note the shield over the IF/first-audio amplifier valve, which minimises IF signal radiation and hum pick-up.



This view shows the parts layout under the bottom section of the chassis. This section mainly supports valves V2 & V4 (ie, the 6A8G converter & the 6X5-GT rectifier) and the mains transformer.

reliably across the entire tuning range without resorting to tricks like padder feedback. It maintains a more constant degree of feedback between the primary and the secondary windings than the circuit used by HMV in the A13B.



This slightly revised oscillator circuit uses the same parts but provides better performance than the original.

To prove the effectiveness of this slight circuit modification, try modifying a set using the HMV-style circuit to that in Fig.2. Receivers with 6A7 converters appear to benefit a great deal from this modification and the sensitivity of the set often improves noticeably.

The output from the converter (at the plate of the 6A8G) is fed to the first IF transformer (IFT1) and then to the grid of IF amplifier stage V2, an EBF35. From there, the IF signal is fed to a second IF transformer (IFT2) which then feeds the detector diode in V2.

As an aside, note that C6 and C10 in the first IF transformer have different values, ie, 100pF and 50pF respectively. This means that, unlike IFT2 where the values are equal (100pF), the inductance of IFT1's secondary is double the value of its primary. As a result, it's not a good idea to swap these two IF transformers (or use an incorrect substitute for IFT1), as the IF gain and hence the sensitivity of the set would be degraded.

The detected audio signal from V2 is fed to the top of volume control VR1. It then passes via C14, R10 and the secondary of IFT1 to the grid of V2, where it is amplified (along with the IF signal). The resulting amplified audio signal is then fed through the primary winding of IFT2 to resistor R16 (20kΩ) and from there to the grid of V3, a 6V6-GT audio output stage, via C18 and R18.

V3 in turn drives the loudspeaker via a speaker transformer.

Note that because V2 acts as both as an IF amplifier and audio amplifier, some compromises have been made in regards to some of the component values around this stage. This means that it may not provide the maximum gain that would otherwise be possible, either as an IF amplifier or as an audio amplifier. The usual compromise is to restrict the audio gain to around 15, whereas if the valve had been used purely as an audio amplifier, its gain could be well over 100.

Getting back to the output stage, the 6V6-GT's grid has -10V bias applied to it from the power supply's back-bias network. In addition, negative feedback is applied from the secondary of the audio output transformer to the bottom end of volume control VR1.

Tone control

The tone control is extremely simple and consists of switch S1 which switches capacitor C20 in or out of circuit. In addition, resistor R19 and capacitor C21 between the 6V6GT's plate and chassis form an elementary fixed tone control. The capacitor has a reactance of about 5kΩ at 3.5kHz, giving a combined impedance for the series resistor-capacitor combination of 10kΩ at this frequency. This impedance drops to just 7.5kΩ at 7kHz.

Power supply

The power supply is quite conventional and is based on a power transformer and a 6X5-GT full-wave rectifier (V4).

As shown in Fig.1, the power transformer primary is tapped for 200-225V mains supplies and for 226-250V supplies (40-50Hz). There are two secondary windings: a heater winding

of 6.3V and a 520V centre-tapped HT (high-tension) winding (ie, 260V either side of the centre tap). Note that the centre tap is connected to chassis via two series resistors (R14 and R7) and these are used to generate the back-bias for the various valves.

The 6X5-GT rectifier produces nearly 270V DC at its cathode and this is applied to the plate circuit of the 6V6-GT via the speaker transformer's primary. By contrast, the HT voltages for the plate circuits of V1 & V2 and the 6V6-GT's screen are obtained via parallel resistors R12 and R13, which limit it to around 185V. The screen circuits for V1 & V2 also have additional filter components connected to their supply lines.

A back-bias voltage of about -2.2V is applied to V1 and V2 and this is obtained across resistor R7 (40Ω). This back-bias is applied via R9 and R8 to the AGC diode in V2, so this receiver has delayed AGC (automatic gain control). The back-bias voltage is also applied via R2 to V1, which receives the full AGC bias developed at the AGC diode.

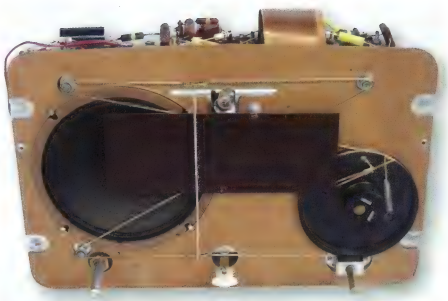
V2 also has -2.2V of back-bias applied to its grid. However, it only receives around 9% of the AGC control voltage compared to V1.

The reason that only a small percentage of AGC voltage is applied to V2 (the IF amplifier-cum-audio amplifier) is simple. Its operating conditions are a compromise and any major variation in these conditions could result in distortion and overload. In addition, because AGC reduces the gain of the IF amplifier stage, it's obvious that it also reduces the gain at audio frequencies as well. So if too much AGC voltage is applied, the audio output could become quite weak in the presence of strong station signals.

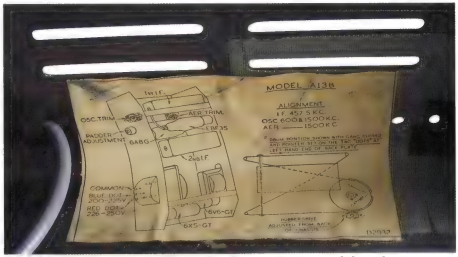
However, with careful circuit design, it's possible to come up with a good compromise to maintain a constant audio level regardless of the incoming signal strength.

Servicing access

Access to the chassis is gained by removing two screws from the rear section of the cabinet and then slipping the back off. Once this is done, the unusual layout of the receiver is immediately obvious. It has a C-shaped "twin-chassis" arrangement, with the parts mounted mainly on two horizontal sections, one at the top and the other at the bottom. The vertical section carries the loudspeaker and the dial-drive components.



The loudspeaker is attached to the front vertical section of the chassis and sits partly behind the dark backing material for the dial scale.



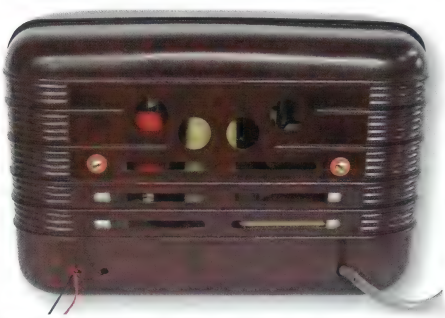
A label inside the cabinet indicates the alignment points and the valve types (and their locations). It also shows the dial-cord arrangement.

To remove the chassis, it is first necessary to remove both knobs and centre the tone control switch between the two rotary controls. It's then just a matter of removing four mounting screws, after which the chassis and cabinet front can be separated.

Once the chassis has been removed, it's easy to access all the parts, including the dial-drive mechanism. Most of the larger parts, including the coils and transformers, would rarely (if ever) require replacement. Only the occasional valve replacement would be necessary.

Two large holes in the bottom section of the chassis provide access to the bottom tuning slugs of the IF transformers. Note that the circuitry around the IF/first audio valve is shielded to minimise IF signal radiation. This shielding also helps prevent the audio stage from picking up mains radiation, which would cause audible hum in the output.

The chassis layout and wiring of this set are quite logical and access for normal service is a dream compared to many other sets. A label on a curved section inside the cabinet shows the valve types, the dial-drive layout and the locations of the alignment adjustments. It also shows the mains winding taps for the transformer primary.



The rear section of the cabinet has four large "finger holes" so that the set can be easily picked up and carried. Undoing the two screws allows the rear section to be removed and provides good access to most parts with the chassis in-situ.

So even without a circuit diagram, it's not particularly difficult to find your way around this chassis. However, because it is a reflex set, a circuit diagram is handy when working around that IF/audio amplifier stage (V2), as this stage is more complex than in many other receivers.

Restoration

This old HMV A13B was overhauled and restored to full working order by its owner (Mark) and one of his friends. First, the figure-8 power lead was replaced with a 3-core cable (securely anchored using a cable clamp) so that the chassis could be safely earthed. That done, the capacitors were all checked and quite a few were found to be electrically leaky, with resistances of just a few megohms when they should have been greater than 200MΩ (and preferably in excess of 1000MΩ).

Several of the electrolytic capacitors had also gone low in value and so all the electrolytics were replaced as a matter of course. A number of out-of-tolerance resistors were also replaced but all the valves checked out OK.

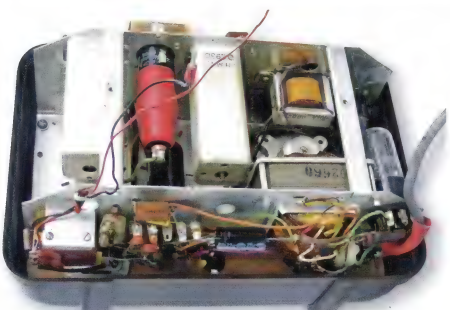
This work solved an annoying intermittent crackling in the audio that had previously been evident. In fact, the set then performed so well that the IF stage alignment was left alone. It may have been possible to wring just a little more performance out of the receiver if an alignment had been done but it was thought that this was already was close to optimum.

Keep the leads clean

As an aside, my own supply of resistors and capacitors is quite extensive. Most of these parts are new-old-stock (NOS) and often 20-30 years old, which means that their leads have tarnished in many cases.

As a result, when using these parts, I have to carefully clean the tarnish off using sandpaper and sometimes even a scraper to get down to bright metal which can be soldered. Neglecting to do this would result in bad solder joints and could easily introduce numerous new faults into equipment that was being serviced.

Mark didn't have this problem because his replacement parts were purchased new. However, it's still something to keep in mind if using parts that you've had stashed away for some time.



Another view inside the old HMV A13B with the rear section of the cabinet removed. Two holes in the bottom section of the chassis provide easy access to the adjustment screws of the IF transformers.

Summary

HMV has always produced well-designed receivers and this set is no exception. However, as stated earlier, the oscillator circuit has some minor shortcomings and I much prefer the circuit shown in Fig.2. The components used in this revised circuit are the same as those used in the original but from my experience, it offers better performance.

The oscillator circuit used by HMV in the A13B wasn't unusual though. The same configuration was used by other manufacturers, including AWA, and "Radio & Hobbies" magazine also used it in many of their AM receiver designs.

Apart from my beef about the oscillator circuit, the rest of the circuit is to HMV's customary high standard. The performance of the set is also very good and I would be happy to have one in my collection. SC

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Better power supply for DAC unit

I have constructed many of your projects over the years; mostly audio and test gear. As I write, I am listening to a system with your 20W Class-A Amplifier at its heart. It's a great amplifier that has enabled my old Tannoys to sing anew!

The reason for my email is in regards to a recent purchase of an Arcam "r-DAC" digital-to-analog converter that is powered from a cheap switchmode plugpack. I have read on the web that this unit is "much improved" with a better power supply. The r-DAC requires 6V at 600mA into a standard DC power connector.

Several years ago, I built your Studio Series Preamp Headphone Amplifier into a box with its own power supply. I can't continue without expressing how much enjoyment that little unit and a pair of Sennheisers have given me over recent years! The power supply uses your circuit board (01109052 Rev B) which has a dedicated 5V supply branch circuit. That particular board uses a 5V, 5W zener diode (1N5338B) instead of a 100Ω 5W resistor before the 7805 regulator as was the case with a previous version.

So to my queries. Firstly, how critical are the voltage and current parameters to the safe operation and sound quality of the r-DAC? Secondly, can the present 5V circuit in the headphone amplifier power supply be modified to produce 6V at 600mA – or whatever is required to efficiently run the r-DAC? Finally, if the modification can be made, will supplying the results to the r-DAC via the standard DC connector improve the sound as is rumoured – or is it all nonsense?

The increase in popularity of DACs as stand-alone improvers of sound quality from computers is in no doubt. Nor is the fact that they actually work – there is a genuine improvement in sound quality from my laptop via the r-DAC. Coupled with your Studio Series Headphone Amplifier and good headphones, the improvement is nothing short of thrilling!

If improving the power supply to the r-Dac does in fact improve the sound quality and that can be done via modifications to the redundant 5V branch of the abovementioned supply, it seems to me to be the possible beginnings of a beautiful relationship that can be replicated by others. (P. G., via email).

● It is possible but unlikely that an analog supply would give markedly better performance. If that were so, wouldn't the original manufacturer have done this and claimed even better performance?

You could modify the unused 5V supply in the Studio Series preamplifer to provide 6V at 600mA by replacing the 7805 with a 7806. But this would be very inefficient and you would need to fit a large heatsink to it. A better solution might be to use a 9V DC plugpack and connect a 7806 (with smaller heatsink and bypass capacitors) to its output.

12V 15A variable power supply wanted

I am looking for a 12V variable motor controller to operate a battery supplied winch to 15A (approx.) that can have current limiting adjustable/set to match the motor at full load current (FLC). With this set, the motor won't overload and rely on the fuse for protection. Which project can you can recommend? (D. O., New Plymouth, New Zealand).

● Funnily enough, it seems that the only speed controllers we have published which had over-current control were those for model train controllers. Typically though, these were only

Speaker Protector Does Not Like AEM 6000

I have built two loudspeaker protector kits (SILICON CHIP, July 2007) for an AEM 6000 power amplifier. The first one passed all tests that day, ran fine all day but next day the relay started to turn on and off about every nine seconds. I made another protector and it will run for hours OK then start going on and off.

I used a 15V transformer for AC sense. Before this mess I made an Ultra-LD Mk.2 amplifier with another protector and they ran fine. The Ultra-LD amplifier didn't have the power of the AEM 6000, so I bit the bullet and took the protector out of the Mk.2, changed resistors, fitted it to the AEM 6000 and pretty soon it started going on and off.

I gave up and next weekend I bought a Rotel RB-1582 power amplifier. After a few weeks, I knew I preferred the 6000. Any ideas? (V. S., via email).

- The first thing to check would be where the source of the switching is coming from. Perhaps the DC output of one of the amplifiers is rising above about 1V and causing the speaker protection to operate. Or maybe the over-temperature switch is cycling open and closed or perhaps the DC supply or AC supply are too low in value or intermittent.

Check that the correct value for R1 is used for your DC supply voltage as shown in the table accompanying the circuit.

rated for up to 6A although it would be possible to increase that.

To take the simplest example, the Li'l Pulser Train Controller from the February 2011 issue was based on an MTP3055 Mosfet and was limited to 2A. It would be possible to modify the basic circuit to provide a much higher current limit by reducing the current sensing resistor and using a much higher rated Mosfet. However, the PCB itself could definitely not withstand the higher currents.

Modifications to voltage switch project

I have just built the Voltage Switch (SILICON CHIP, December 2008) and all works well. However I am not using it in a car but in a battery discharge unit I am building. Your circuit will disconnect the load when the the battery falls to a preset level. I want to put a digital voltmeter from pin 3 to earth so that whoever is using this device can see exactly what the cut-off voltage is when they adjust it with VR1.

But as designed, this voltage reading will be half of the actual cut-out voltage. I want to be able to see the actual cut-out voltage during adjustment. So if I did away with the two 1MΩ resistors, what is the maximum voltage that can be applied to pin 2?

I would also supply a stable voltage to the top of VR1 which is also limited by the maximum voltage that can be applied to pin 3. The maximum voltage I would like to be able to apply to pin 2 is 36V and to pin 3, 30V. Is this within the IC's range? (I. S., via email).

- Unfortunately, the LM358 cannot be used with input voltages that approach the supply. That is why the input is first attenuated. To do what you want, you would have to replace the LM358 with a high-voltage rail-to-rail op amp such as OP213 or OP284.

Alternatively, you could retain the LM358 and simply amplify the pin 3 voltage by a factor of two using a separate op amp. Then the voltmeter would show the correct voltage. Maximum supply for the LM358 is 32V so the supply would need regulating with a 36V source.

How to log an AC voltage

I have built the USB Data Logger from the February 2011 issue of SILICON CHIP. What I could not understand is where do I add a second connector for an analog sensor, like a small voltage source? Do I connect one wire to an analog port, say A0, and other to the GND? Or do I use port A0 and A1? I am trying to log an AC voltage. (Z. Z., via email).

- The simple answer to your question is that you connect it between A0 and GND and if you have another sensor, between A1 and GND and so on. Usually one pin is marked as the reference or ground and this is the one that goes to the GND terminal.

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Timer Wanted To Stop Excessively Long Showers

Given the substantial increases in electricity prices and that a household's electric hot-water system is usually the largest user, a "shower timer" would be a great idea. We have three teenage boys. And despite understanding the cost situation and assuring their parents that they will keep their showers to a minimum, their memories tend to fail them when the water hits their skin!

We have tried both egg timers and electronic stopwatch timers without success as they either forget to start them or just ignore them. What I am thinking of is a timing device that is triggered automatically by the start of the shower, with a visual and aural warning that is loud enough to annoy both the showering person, plus let those outside the bathroom know that the time period has elapsed.

Obviously the device needs to be waterproof and detect the start of the shower (eg, the sound of the water or the air/plumbing temperature)! It needs to hang from the shower or tap, have an internal preset timer (not easily adjustable) settable in seconds or 30-second increments, and an aural (piezo?) and visual (high-brightness LED) indicator.

A low stand-by current would be helpful to extend the battery life and maybe flash the LED when the battery voltage is getting low. Given the cost of electricity and the resulting shorter showers, the savings should easily pay for a project such as this in one billing period. (R. M., Wollongong, NSW).

● We actually published a Shower Timer in the January 2005 issue but the kit is no longer available. However, it is not worth revisiting because you can now buy the same sort of thing on eBay and elsewhere.

Actually, for teenagers a timer is probably not enough. You need a powerful sanction such as the hot water being turned off after a preset period such as four minutes. However, we cannot think of any easy way of doing that apart from having a timer-controlled solenoid which would have to be plumbed into the hot-water line to the shower.

In more detail, analog sensors typically have either two or three wires. For 3-wire types, these will be power, ground and output. The ground pin is shared as a return path for power current and as a reference voltage for the output.

With a single 3-wire sensor, you connect the power pin to the 3.3V output (or some other voltage source), the ground wire to GND and the output to one of A0-A3. If you have more than one of these sensors, the power and ground pins are all wired back to the same point while each output goes to a separate analog input on the Data Logger, eg, A0 and A1.

For 2-wire sensors, the situation is the same except a single pin is used for both the power supply and signal output. The ground wire goes to GND and the output to one of A0-A3. A resistor is then connected from the output pin to a power supply rail (eg, 3.3V).

Note that if your sensor's AC output can swing above and below ground, you may need to add a DC offset to it as the logger will only sense voltages above ground. This can be done with a capacitor and two resistors or with an op amp circuit, depending on whether it's OK to discard the DC component of the signal from the sensor.

Speed control for a small lathe

I have small model lathe that has a 230V DC 3A brush motor. I'm searching for a unit with 230V 50Hz single-phase input and 0-220V DC output which I can construct at home. I've searched the internet and found premade modules such as the Parker 506 3A Drive but the cost puts this out of my financial reach. (P. R., via email).

● We assume you want a speed control. We published a low-cost design in February 2009 and it is available as a kit from Jaycar, Cat. KC-5478. A 230V DC motor should run OK from the half-wave rectified mains output of this speed control.

If you want much smoother control over a much wider speed range, you would be better off building our 10A Full-Wave Motor Speed Controller from the May 2009 issue but it is more expensive. It is also available as a kit from Altronics (Cat K6035) or Jaycar (Cat KC-5478).

Solar panel theft alarm wanted

Can your Driving Light Protector kit (SILICON CHIP, September 2002) also be used to help stop theft of solar panels? My situation is that I have two 80W 12V solar panels connected in parallel, which I use when camping.

Practically, it's a bit difficult to bolt them to the roof of the tent so the panels are pretty much unsecured and so potentially attractive to opportunistic thieves around the camp-ground. This situation is made worse by usually needing to place the panels near to the edge of the camp-site boundary so as to be in the sun and out of the way.

I'm hoping that the alarm would work on the same principle, ie, disconnect the cabling to steal the panel and an alarm immediately sounds, drawing attention and making a thief think twice about walking away with a $300 solar panel or two. From my reading of the article I could run a third wire out to the panels, connected to the negative side at each junction box.

If this third wire or the negative of the feed-in cable is subsequently disconnected, the alarm will sound. Am I also right in my thinking that for the circuit to work I would also need to have a link from the negative lead of the panels, at the PV charge controller, to the earth of the kit? Then if this earth on the driving light protector is connected to the battery negative, the PV charge controller would also be connected to the battery negative.

Would this be a problem, as the PV controller has separate positive and negative inputs and outputs for the panels, battery and load? (T. H., Calwell, ACT).

● Yes, that should work. You could run a (third) wire from each solar panel negative terminal to one input of the driving light protector. Then the driving light protector earth connects to the panel negative terminal of the PV charge controller. The main charging wire from the negative of the PV charge controller to the negative of each solar panel should be left connected.

Note that these added third wires to each panel must be connected so that when disconnected from the solar panel, they will not remain in contact with the panel's negative output lead or the alarm will not sound.

One option is to secure the third wire to a separate negative terminal of the solar panel (if available). If there is only one negative terminal, then the two wires should not be twisted together, so that the wires will be separate if disconnected.

Alternatively, the wires could be terminated using separate eyelet connections on the same earth screw.

Relay modification for Power-Tool Soft Starter

I recently constructed the Soft Starter from the April 2012 issue and I am now getting together the parts I need to build the Power-Tool Soft Starter from the July 2012 issue but I have a small problem regarding the relay.

I have a relay on hand that is exactly correct in all aspects except for the fact that it has a 12V coil instead of a 24V coil. Being on a tight budget, I would like to use this relay as I cannot easily or cheaply obtain the correct 24V coil version.

I see two possible modifications to the circuit to enable the use of the 12V coil relay and I would like to ask your advice on this. Option one would be to connect the collector of the BC557 to 0V instead of -12V. Would this work or is there some reason it wouldn't?

Option two would be to add a resistor in series with the relay coil. The relay I have has a DC coil resistance of 355Ω. I was thinking that maybe a 330Ω or 390Ω resistor would be suitable. Possibly a 12V zener diode across the relay coil would also be needed? Would this be a viable option?

Either option could be accomplished with a simple modification to the PCB, option two being the easiest to accomplish by simply cutting one track and bridging this with the series resistor. (B. P., via email).

- The specified relay has a coil resistance of 1100Ω. On that basis, if your relay has a coil resistance of 355Ω, we suggest connecting it via a series resistor of 390Ω or 470Ω. No zener would be required but note that the coil would be driven at less than 12V. A 12V relay should still latch when driven at 9V.

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Bigger display LEDs for the Bass Blazer

I am building a bass amplifier and I would like to build a Bass Blazer (SILICON CHIP, February 2001) into it. I would, however, like to use 20 block LEDs instead of the 20 single LEDs for a much bigger display. This would mean that instead of each display step turning on a single LED, it would turn on eight LEDs in a block. As the LEDs are powered from a constant current supply of 10.2mA, I'm guessing that this may need to be increased.

The LED blocks I want to use are Kingbright KB-

Antennas For DAB+ Reception

I am a radio fanatic from way back and interested in digital radio. Living in Shellharbour I was told that it is not available yet.

Undeterred and being close to Sydney, I did buy a portable DAB+ radio. As expected, no signal was found but it still has FM. In June 2012, the analog TV signal was switched off in this area, so I gave the DAB+ radio another go and found it did receive the stations from Sydney. The signal is not very strong and is only available in certain spots in the house but it is very clear.

The thing I would like to know is what will happen when digital radio is started in our area? Will the stations from Sydney be boosted or will we receive our local stations only and the Sydney stations blocked? I do think a lot of people would like to know this. (T. P., Shellharbour, NSW).

- If you can receive DAB+ in Shellharbour with the portable radio's own whip antenna, you should get better reception if you use an external antenna, especially if it is cut to suit the DAB+ frequencies. Failing that, a TV antenna which will receive VHF Band 3 will also receive DAB+ broadcasts.

The reason for suggesting an external antenna is that when (and if) you get DAB+ broadcasts in your area, there is no guarantee that DAB+ stations from Sydney will necessarily be relayed or if they are, not all of them might be.

DAB+ antennas are available from local manufacturers and on eBay.

Low-fuel Warning For A VW Transporter

I own a 1977 Volkswagen Transporter which has a good functioning fuel indicator but it lacks a low-fuel warning light. Therefore I was looking on the internet for something which can provide this feature.

Unfortunately I haven't found anything which suits; only an old Low-Fuel Level Indicator kit published during the 1990s. As this kit is no longer available I would like to try to build it with universal parts. Therefore, I would like to ask you if you can provide me a parts list and the building instructions. If it works, I probably will try to make a circuit board for it.

I hope you can help me with my strange request. (M. H., Stedebroec, Netherlands).

● Our Voltage Switch project as published in the December 2008 issue can be used for this application and this would be the easiest approach. It is available from Jaycar, Cat. KC-5377 (**www.jaycar.com**).

H100SRDs. Would it be as simple as putting in a lower value/higher-wattage resistor to replace the 68Ω supply resistor or would I need to also change transistors Q1-Q4 for higher current ones? Does it also perhaps require heatsinks on the transistors and a higher power plugpack for the supply? (P. S., via email).

● Unfortunately the circuit for the Bass Blazer is limited to a 10mA LED current. That's because the LM339 comparator outputs can only sink up to 10mA. So while it would be possible to increase the flow from the constant current source, the LM339 outputs cannot sink the current in order to switch LEDs off.

The only way to have more LEDs driven for each level threshold is to parallel the inputs of extra LM339 comparators (one for each extra LED). The constant current circuit should be duplicated for each extra LED string using a BC557 and 68Ω resistor. Alternatively, the current source can be increased to provide 70mA to drive the total LED bargraph for each frequency. This is done by changing the 68Ω resistor to 10Ω .

The BC557 transistors would need changing to BD140 types with a heatsink to dissipate up to 1W. Note that you should also add a 10Ω resistor between the output pin of the top LM339 comparator and the current source to provide current sharing in each added LED string.

Phone timer for call centre

I am writing to find out if you have anything about an in-line phone timer. I work in a counselling service call centre and our clients get to have a 15-minute call each night and I need some way to cut the phone each 15 minutes so there is no conflict with the next client to make a call. The phone system is VOIP and the suppliers say they are unable to help.

I am thinking of maybe an in-line clock with a 5-second cut and reset timer every 15 minutes, with displayed countdown timer. Are you able to point me in the right direction to get or have one made? (D. N., Nowra, NSW).

● Possibly the Telephone Timer from the July 2001 issue could be made to work although it works in the opposite way to what you want and it is powered from the telephone line. The VOIP telephone may operate differently to a standard phone line service but it still will have an off-hook/on-hook switch when you lift the handset.

The timer could be used to close the handset switch when the timer has timed out. The time settings can be altered by changing the 470nF capacitor at pin 9 of IC1. Halving the value from 470nF to 220nF will give the required 15-minute timeout on the 30-minute setting.

The idea would be to use the 5.6V circuitry and dispense with transistor Q2 and the collector resistors and replace the 1kΩ collector resistor for Q1 with a 5V reed relay between the collector and the 5.6V supply. The relay contact can then be connected in series with the on/off hook switch (or in parallel, depending on how the on/off hook switch operates).

The start switch would need to be pressed in order to make a call and the timer will disconnect after the timer period.

Questions on the LM317 adjustable regulator

I have a couple of queries regarding the LM317 regulator. I need to use it to get 5V from a 24V input and I'm a little confused about how I select the values of the input capacitors. The data sheet suggests 0.1μF to 1μF.

However, what other factors could affect the selection? For example, in my case, the input lead from the 24V battery to the regulator could be 2-3 metres. Would having such a long cable which could pick up noise influence the capacitor selection and

continued on page 96

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Ask SILICON CHIP

. . . continued from p94

what values would you suggest for my situation?

Finally, I'd like to include some over-voltage protection just using a zener diode. How is the value of resistor chosen? It usually seems to be a low value like 10Ω. (B. W., via email).

● The input capacitor for the LM317 is not critical and can be a larger electrolytic capacitor than the recommended 100nF and 1µF values. The higher value would minimise the effect of lead inductance for a long connecting lead.

Typically a 10µF electrolytic capacitor would be suitable. This should be rated at 35V for the nominal 24V battery (which could reach close to 30V when charged). For added decoupling, connect a 100nF MKT capacitor in parallel with the 10µF electrolytic capacitor.

A protection zener diode across the input could be used and should be a 30V type so that it clips transients and is not conducting with normal supply voltage. A 10Ω series resistor would be suitable but would need to be rated for the current drawn from the regulator.

A 20W resistor would be needed for 1A. This could comprise two series 4.7Ω 10W resistors or paralleled 22Ω 10W resistors. Alternatively, for 100mA drawn from the regulator, use a larger value such as 100Ω 5W.

SLA batteries cannot be rejuvenated

I purchased the Battery Zapper/Rejuvenator kit (SILICON CHIP, October 2009) with the understanding that it would bring uncharged sealed lead acid (SLA) batteries back to life but on reading the instructions it says it only work for car batteries.

I may have to return this kit because of this and would like some urgent help with the SLA battery issue. I'm aware of the need for a battery charger to power the circuit and just to twist the plot, can this be a solar panel instead (I have a 20W unit for experiments)? (R. S., via email).

● A solar panel could be used – good idea! But sealed lead acid batteries can't be rejuvenated. If they have been discharged below 11V, that generally means death. SC

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Notes & Errata

PIC/AVR Programming Adaptor Board (May-June 2012): since this circuit was designed, Microchip have released a number of new PICs, many of which can be programmed using this board. This includes the PIC16F150x series (four chips). These can be programmed in mode B, not mode C as is implied by Fig.5 on page 78 of the June 2012 issue.

For other new PICs, check the data sheet and compare the programming pin location and supply voltage requirements to that of other micros listed in Fig.5.

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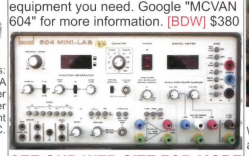

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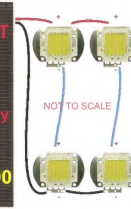

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